RADIO and ELECTRONICS

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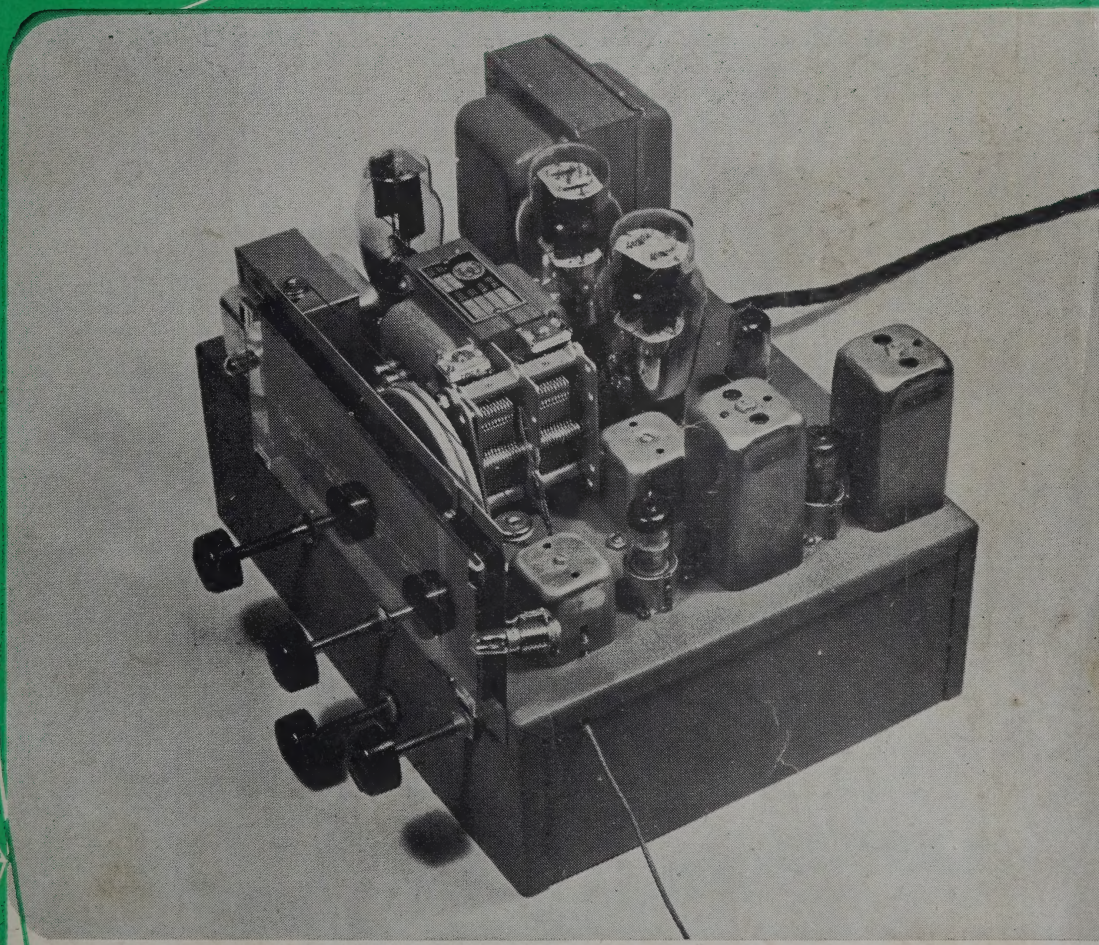

In this Issue:—

THE 7-VALVE RECEIVER ILLUSTRATED ABOVE

SEPTEMBER 1, 1948 VOL. 3, NO. 6

1/10

Another "Five Star" SMASH HIT!

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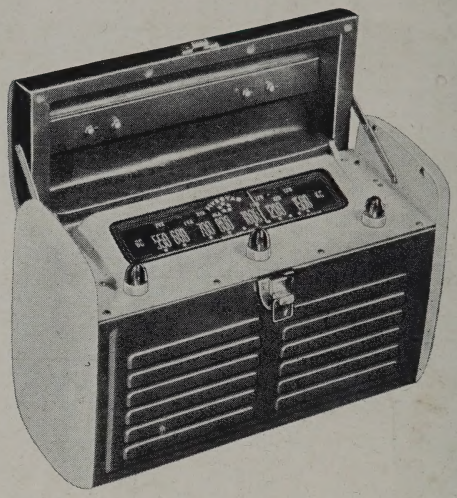

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RADIO and ELECTRONICS

Vol. 3, No. 6 1st September, 1948

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OUR COVER

Our cover this month shows a general view of the Seven-valve Quality Broadcast Receiver described in this issue on page 10 and succeeding pages. Chassis diagram and under-chassis view are to be found with the story. The set has push-pull triode output with built-in heavy-duty output transformer, a cathode-coupled phase inverter, and variable-selectivity I.F. amplifier, using commercial I.F. transformers of the tertiary winding type, giving two-point selectivity. The "broad" position gives really high-quality reception from the local stations, and from distant ones, too, under suitable reception conditions. At the same time, the sensitivity is adequate for long-distance reception.

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GUY E. MILNE
ELECTRONIC TECHNICIAN

Membership in The N.Z. Radio Traders' Federation

The New Zealand Radio Traders' Federation is an association which comprises manufacturers, wholesalers, and retailers engaged in the radio industry. It can therefore claim to be truly representative in scope, and, as those members of the trade and industry know who belong to it, it has had considerable success in achieving its avowed objects.

What, then, are these aims? They are to make the Federation a meeting ground where problems common to the whole or any part of the industry can be discussed, and to perform any duties that can be usefully carried out in behalf of the industry as a whole. It stands to reason, as a little thought will show, that in these troublous times, in particular, any major industry must have a host of problems. Some of these can be solved, temporarily, by individual firms while others cannot be solved at all except by concerted action of the industry as a whole.

It is in this last phrase that the key to the Radio Traders' Federation is to be found. For, except insofar as the Federation acts in the appropriate capacity, the "industry as a whole" does not exist. This is most important, and the Federation has made it its business to take action, and very successful action, too, in a number of matters that have been the concern of the whole industry. For example, the Federation has been active in maintaining the trading margins allowed to the industry. It has been successful in having lifted a number of import embargoes which adversely affected the industry. It has been instrumental in obtaining a separate award, recently promulgated, for radio workers, and it keeps an ever-watchful eye on such things as the maintenance of proper trading conditions, and ensuring the adequate certification of employed personnel. It is able to meet the Government at various times to discuss controls that affect the industry, and to put their point of view. For all these purposes a body such as the Federation is absolutely necessary, since no single firm or persons can claim to speak with the industry's authority, nor can the concerted action of which we spoke be taken.

So much will be largely self-evident to anyone who has thought about these things at all. One would therefore expect to find that the Radio Traders' Federation can count among its members almost 100 per cent of all those eligible to join its ranks. Unfortunately, this is by no means the case. For some time the Federation has been concerned at its small membership in comparison with its possible strength, and now the Executive is taking active steps to increase its membership.

There are, it seems, a number of people who are perfectly happy to sit back and take for granted the successful efforts of the Federation, and to take equally for granted the benefits that accrue to themselves, in spite of the fact that they give the Federation no active support. Others may possibly be ignorant of the work of the Federation, and will no doubt hasten to become members when they realize the excellent work that has been done in the past, and the important role that it can play in the future.

There seems to us (and we have no axe to grind in the matter, being of the industry, but not in it) no good reason why the Federation should not have much more active support from members of the trade than it does at present. It is in everyone's own interest to do so, for as the industry grows, there is no guarantee that if membership does not increase the Federation will continue to be as successful as it has been. There is no doubt that industrially, radio is a power in the land, but if through ignorance or apathy its voice, though representative, is only a small one, it is reasonable to suppose that its collective achievements will be only a small fraction of what could be attained.

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The "Radio and Electronics" Portable Competition

As announced in last month's issue of "Radio and Electronics," the Editors have decided to organize a competition for amateur set-designers for the best set of drawings, accompanied by a written description, for a dry-battery operated portable receiver. We have pleasure, therefore, in presenting below the details connected with the competition. The conditions of entry and the method of judging are clearly set out, and we would ask intending competitors to read the whole very carefully to make sure that all the necessary requirements are complied with before an entry is submitted. **NON-COMPLIANCE WITH ANY OF THE UNDERMENTIONED CONDITIONS WILL CONSTITUTE SUFFICIENT GROUNDS FOR DISQUALIFICATION, SUCH DISQUALIFICATION TO BE MADE ONLY BY THE JUDGING COMMITTEE.** In the selection of the prize-winning designs, the decision of the judges will be final.

CONDITIONS OF ENTRY

(1) This competition is open to any person who, both at the time of entry and at any previous time, has not been professionally engaged in radio.

(2) Each design submitted must be accompanied by an entry form cut from this page.

(3) Any competitor may submit any number of entries, provided that EACH ENTRY is accompanied by a separate entry form, as laid down in (2) above.

(4) Each design submitted must be the result of the unaided work of the contestant whose signature appears on the entry form attached to the entry.

(5) The competition is for the design of a dry-battery operated portable radio receiver. The term "portable radio receiver" is hereby defined as "any radio receiver capable of being carried in the hand, which derives its operating power from dry batteries inside the framework or case which holds the receiving equipment, and which requires the attachment of no external power supply or aerial in order to operate on the standard broadcast band of 550 to 1600 kilocycles per second."

(6) The designs will be in the form of drawings and written description only. **IT WILL THEREFORE BE UNNECESSARY FOR THE RECEIVER WHICH IS THE SUBJECT OF AN ENTRY TO HAVE BEEN BUILT BY THE DESIGNER.**

(7) The material submitted with each entry MUST include the following:—

(a) **A circuit diagram,** complete with the values of all components, other than R.F. and I.F. coils and transformers. Components not specified electrically, i.e., coils, I.F. transformers, loudspeakers, etc., must be specified by stating the manufacturer's name, and, where possible, his type number. Details such as the intermediate frequency intended to be used in a superheterodyne circuit should on no account be omitted.

(b) **A chassis lay-out diagram** showing the placement and size of all mounting holes, and indicating where major components are intended to be placed.

(c) **A working drawing** of the chassis, presented in such a way that this drawing could be used from which to make all the necessary metalwork.

(d) **A general lay-out diagram** showing the relative positions of batteries, chassis, aerial, and controls and their method of mounting. This diagram should be dimensioned in such a way that it can be used as a working drawing for the construction of the cabinet.

(e) **A written description** of the design, which should enlarge on any necessary details not covered by the above drawings.

(8) Paragraph (7) above should not be taken to mean that competitors are restricted to supplying **only** the drawings specified therein. Competitors are free to supply as much information, either as drawings or by way of written material, as they wish.

(9) The competitors must be prepared to allow "Radio and Electronics" to publish their designs, should the Editors so desire.

(10) **Last Date for Entries.**—All entries, which must be addressed to the Technical Editor, "Radio and Electronics" (N.Z.), Ltd., Box 22, Government Buildings P.O., Wellington, must bear a postmark dated not later than 15th October, 1948.

(11) **Return of Papers.**—The papers submitted by contestants will not be returned unless accompanied by the following: (a) A covering letter requesting their return after the competition has been decided, and (b) a stamped, self-addressed envelope.

(12) **Australian Entries.**—Owing to difficulties of transport, which make it impossible for us to guarantee any specific date of arrival of this issue in Australia, and which would therefore put Australian readers at a disadvantage on the score of time, it has been decided that this competition will be open only to residents of New Zealand.

(13) **Marking of Entries.**—Each sheet of each entry must be marked in the top right-hand corner with the name AND ADDRESS of the competitor.

(14) **Judging.**—The decision of the judges will be final. The judging committee will consist of three members: Mr. D. B. Billing (Turnbull & Jones, Ltd.), Mr. D. M. Hall, M.Sc. (Department of Scientific and Industrial Research), and Mr. W. D. Foster, B.Sc., A.M.Brit.I.R.E. ("Radio and Electronics" (N.Z.), Ltd.). Designs will be judged strictly on their merits, and points will be allotted for—

(a) **Overall Mechanical Design.**—Under this heading are the points for compactness consistent with practicability, appearance, accessibility for replacement of batteries and valves, ease of servicing, and related matters.

(b) **Mechanical Lay-out of Circuit Components.**—This includes the worth or otherwise of the design when such things as the possibility of regeneration are considered.

(c) **Suitability for Amateur Construction.**—Under this heading come such things as the use or otherwise of standard parts, or the possibility of any special parts being made by the amateur constructor himself. A design will obviously lose marks if it entails work that requires facilities not possessed by the home-constructor.

(d) **Originality.**—While marks will be given for originality in any part of the design, such new features must not detract from the desired performance, nor must they be included at the expense of other desirable features, such as accessibility or good lay-out of the electrical circuit.

(e) **Circuit Design.**—This will be judged on a variety of points, too numerous to give in detail; such things as the suitability of the circuit valves are obviously very important, and marks will be taken off for omissions and for the choice of values which would result in improper operating conditions for the valves.

(f) **Description.**—Points will be given for the clear exposition by the contestant of his objects in designing the set as it is and for the degree to which, in the judges' opinion, the designer's aims have been successfully put into practice. This principle has been laid down to make it clear that a design can win a prize, even if it falls short of others submitted in one respect. The judging will be done in such a way that the best **overall** design wins first prize and so that excellence in one particular aspect alone cannot decide the issue.

(15) **Prizes.**—The following prizes will be awarded:

In conclusion, we would like to thank all those firms who have made prizes available for this competition. It could not have been held but for the generous response of the firms concerned, and we are sure that the attractive list above will be the means of making the competition (which is in the nature of an experiment) a great success.

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3rd PRIZE: £5 WORTH OF RADIO PARTS

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4th PRIZE: £2/10/- WORTH OF RADIO BATTERIES

This prize has been donated by:
The National Carbon Co., Ltd.

5th PRIZE: £2/10/- WORTH OF RADIO BATTERIES

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PORTABLE RADIO COMPETITION

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Address: .....

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Occupation: .....

I submit herewith papers comprising one entry in the above competition. I undertake to abide by the rules of the competition as set out, and to accept the decision of the judging committee.

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Date: .....

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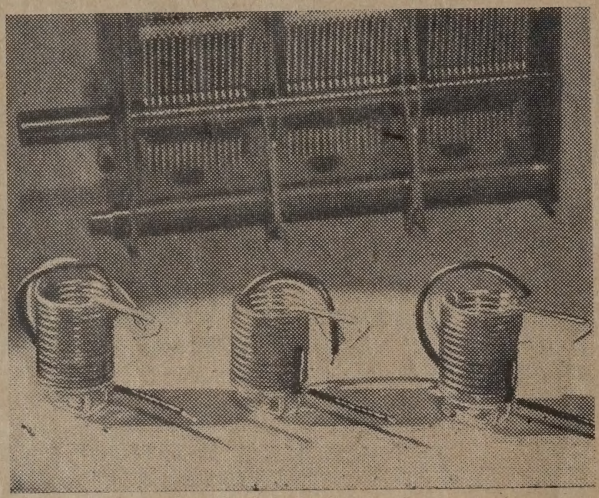

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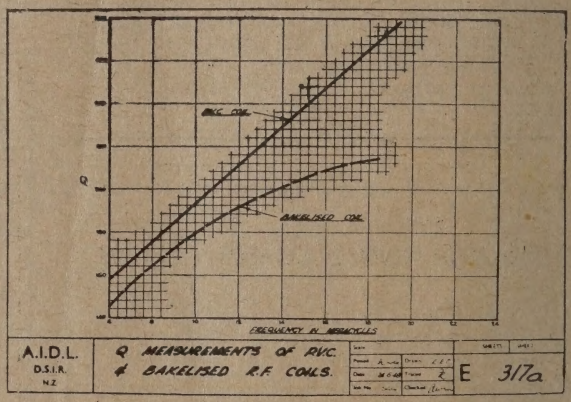
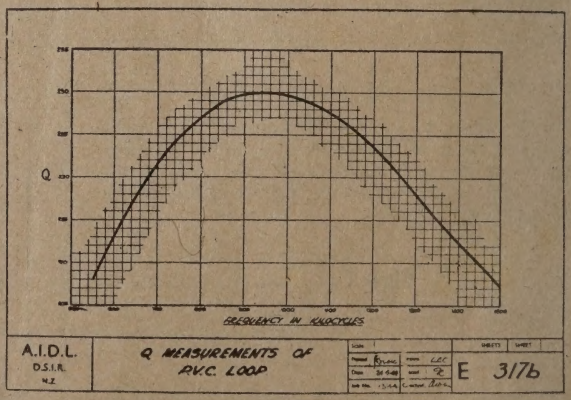
Curves run on the COMPANION plastic loop aerial (N.Z. Prov. Pat. 98153) and standard receiver coils (N.Z. Prov. Pat. 99100) are reproduced on this page. In the case of the loop aerial, it is interesting to note its performance peak in mid-band, and astonishing "Q" figures even at the band limits. The receiver coil is just as surprising, in that its losses do not appear to vary with frequency over the range of measurement, i.e., the graph is a straight line.





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Radio and Sound Engineers,
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The Frequency Response of Resistance-Coupled Voltage Amplifiers

This article explains why all resistance-coupled amplifier circuits show a falling-off of the response at high and low frequencies, and shows how this falling-off can be successfully combated in order to achieve the desirable state of affairs usually described as "flat from 20 to 20,000 cycles a second."

INTRODUCTION

Most people who are interested, for one reason or another, in achieving a "flat" frequency response in their audio amplifiers have some idea of what are the causes of the falling response of all ordinary circuits at high and low frequencies. Many of them, however, are not very clear as to how these causes, and the artifices that are used to circumvent them, react one upon the other. For example, the devices used to ensure that the response remains level to a high enough frequency are sometimes inimical to the realization of an equally good response at the low-frequency end of the scale. In order, therefore, that one may design voltage amplifier stages that have both high and low frequencies extended far enough, and at the same time do not suffer from other related defects, it is absolutely necessary to have a clear mental picture of all the factors involved, and of how the various devices used react one upon the other. With these things in mind, it is a comparatively easy matter to design satisfactory voltage amplifier circuits for any given purpose. If they are not all considered at once, one can easily end up with an amplifier which has excellent low-frequency performance, for example, but which falls badly short either in high-frequency response or in voltage-handling capacity, or in both.

We will therefore consider first of all the basic reasons for the frequency response limitations that occur inevitably in all resistance-capacity coupled amplifiers.

HIGH FREQUENCIES

In Fig. 1 (a) we have the circuit of a resistance-capacity coupled triode amplifier stage. The first thing to be noted about this figure is that we have included, as part of the stage, the input circuit of the next stage. This is because the attachment of the grid circuits of the second stage to the plate circuit of the first, through the coupling condenser C_c, modifies both the frequency response and the voltage-handling capacity of the latter, so that it cannot be considered separately from it. Shown dotted are the inter-electrode capacities of both valves. Although these capacities can be conveniently ignored under some circumstances—namely, when the frequency handled by the amplifier is in the middle and low ranges—they can not be forgotten when it comes to discussing the high-frequency performance, since they form the sole reason for the falling response in these regions.

Fig. 1 (b) illustrates one of the two main causes of high-note loss. In this diagram, the valve has been replaced by a generator, having no internal resistance, in series with the plate resistance of the first valve, which is indicated on the diagram as R_{p1}. The plate load resistor for V_1, viz., R_{l1}, has been shown as connected to earth, in parallel with the output capacity, C_{o1}, of V_1. This simplification is justified, because the H.T. end of the load resistor is at earth potential as far as signal voltages are concerned. Thus, in Fig. 1 (b), we have the coupling condenser, C_c, and the grid leak of the next stage, V_2, with which the input capacity of this valve is in parallel. The capacity is shown as C_{i2}, and not as C_{gc}, because the grid-cathode capacity of V_2 is only a part of its input capacity. The remaining portion of the input capacity of V_2 will be discussed later, under the heading of Miller Effect. Thus, the full circuit of Fig. 1 (a) can be simplified to that of Fig. 1 (b). Looking at this circuit, and remembering that at the moment we are discussing high-audio frequencies, it is easily seen why the response of the arrangement falls off at some high frequency. R_{l1} and R_{g2} are both quite large resistors. Across the former we have the output capacity of V_1, and across the latter is the input capacity of V_2. Now, although these capacities are both fairly small, they bypass the signal to earth, both at the plate of V_1 and at the Grid of V_2. At middle and low frequencies, the capacity of these condensers is so small that they have virtually no effect on the performance, but, as the signal frequency is raised,

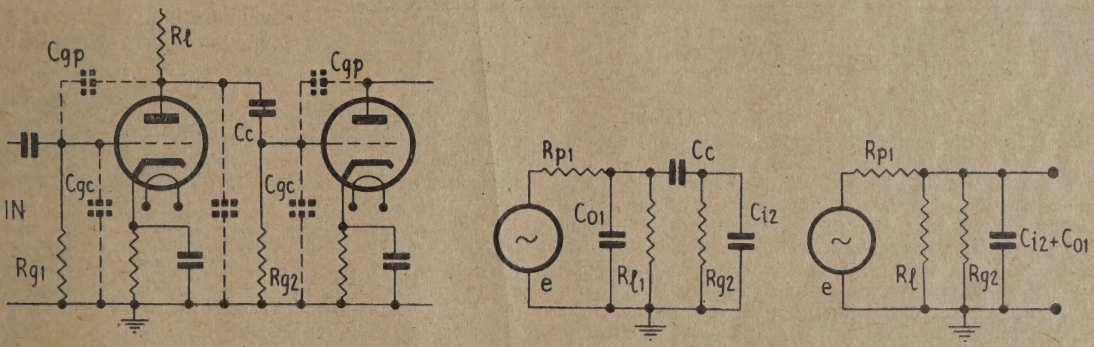

Fig. 1 (a). (b) (c)

their reactance becomes less and less, so that they act more and more effectively as bypass condensers, and the response drops off gradually. Finally, at very high frequencies, the reactance of the capacities is so small that no signal at all remains at the plate of V_1 and the gain of the stage is zero.

Now, the coupling condenser, C_c, has a high value, usually of the order of 0.05 to 0.1 μf., which for the higher frequencies can with all justification be regarded as a short circuit. Thus, when we are considering the high-frequency response of the stage, C_c can be disregarded, and the circuit simplifies even further, to that of Fig. 1 (c). Here we are left with the valve, still represented as a generator, in series with a resistance equal to the plate resistance of the valve; this combination feeds the

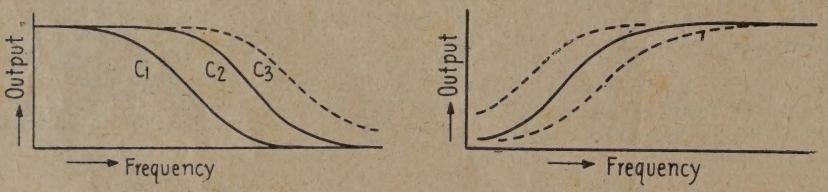

Fig. 2 (a). (b)

combination of plate load resistor, following grid resistor, and the sum of the input and output capacities, all in parallel. This is a reasonably simple circuit, and it is an easy matter to evaluate its performance at high audio frequencies. Without going into the mathematics of the problem, it is possible to illustrate the performance by means of curves. These are given in Fig. 2 (a). At low and medium frequencies, where the capacities can be disregarded, the whole circuit boils down to a simple voltage divider comprising R_{g1}, and R_1 and R_{g2} in parallel. Thus, until the capacities start to have some effect, the frequency response is flat, as shown by the left-hand part of Fig. 2 (a). The three curves labelled C_1, C_2, and C_3 show the effect of three different values of shunt capacity. C_1 represents a comparatively large value of $C_{12} + C_{01}$, while C_2 and C_3 show the effects of progressively lower values of capacity. In all cases the **shape** of the falling part of the curve is the same, but the different values of capacity determine at what frequency the fall in response commences. It is apparent from Fig. 2 (a) that if the shunt capacities can be reduced in value, by some means or other, the falling-off in the high-frequency response is delayed to higher frequencies. Unfortunately, there is a limit to the extent to which the tube input and output capacities can be controlled, so that if we are to control the high-frequency response of our stage, we will have to find other means of doing so. Nevertheless, it is useful to know that the size of the tube capacities do control the high end of the response curve, because to some extent the input capacity in particular is under control in a way that will be explained. However, before discussing remedies, it is necessary to detail all the causes and effects that have to be contended with.

INPUT CAPACITY AND THE MILLER EFFECT

At first sight, it might appear that the input and output capacities are completely controlled by the characteristics of the valves used, and therefore that the only form of control that can be exercised over their values is by choosing valves which have small inter-electrode capacities. This is by no means true, however; the output capacity of a valve is certainly fixed by its plate-cathode capacity, but the effective input capacity depends, not only on the grid-cathode capacity, but on the grid-plate capacity AND on the amplification. Referring back to Fig. 1 (a), it can be seen that the frequency response of the first valve, V_1, depends in some way on the grid-plate capacity and gain of the following valve, V_2. This is why, in Fig. 1 (b) and (c), we have called the input capacity of V_2 C_{12}, and not C_{gc}, for they are not at all the same thing unless V_2 happens to be not working—a condition in which we are not interested!

The first man to discover that the input capacity of a valve is dependent upon the gain and grid-plate capacity was one Miller, after whom the effect has been named. The formula which he developed is a very simple one, and, being so useful in enabling actual input capacities to be calculated, we give it here. In its simplified form it does not take into account the phase shifts that occur at high and low frequencies, but it is nevertheless very useful as an assistant in the design of resistance-coupled amplifiers. It is:

$$C_1 = C_{gc} + (M + 1)C_{gp}$$

where C_1 is the total input capacity, C_{gc} is the grid-cathode capacity, and C_{gp} is the grid-plate capacity, and M is the stage gain. Now all these can be found from the valve data books, including the gain M in resistance-coupled circuits, so that it is possible to work out the input capacity of any valve, triode, or pentode from information that is readily available. To take a few examples: The figures for a 6Q7 are as follows: $C_{gc} = 5.5$ mmfd., $C_{gp} = 1.5$ mmfd., and $M = 45$, under representative conditions. Filling in the formula, we have:

$$C_1 = 5.5 + (45 + 1)1.5 = 74.5 \ \mu\mu f.$$

The input capacity is therefore many times greater than could be accounted for by the valve capacities alone. To take a second example, let us consider a medium-mu triode, say a 6C5. Here we have $C_{gc} = 3.0$ $\mu\mu$f., $C_{gp} = 2.0$ $\mu\mu$f., and $M = 13$. Working out the formula again, it is found that the input capacity is 31 $\mu\mu$f., which is less than half that of 6Q7. Again, taking a pentode, the 6J7, we have $C_{cg} = 7$ $\mu\mu$f., $C_{gp} = 0.005$ $\mu\mu$f., and $M = 82$. This time the input capacity works out to only 7.415 $\mu\mu$f. There is, then, a large difference in input capacity between pentodes, medium-mu triodes, and high-mu triodes, with the latter showing up as by far the worst.

LOW-FREQUENCY PERFORMANCE

At the low-frequency end of the scale the actual circuit of the stage becomes very much simplified, because here the effect of the valve capacities can be completely ignored. The equivalent circuit therefore boils down to that of Fig. 1 (b), from which the shunt capacities have been removed. Now, we have the full amplification of the valve, as before, producing the output voltage at the plate, but the coupling condenser, C_c, can no longer be ignored,

(Continued on page 41.)

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This receiver has been designed specially for those who want quality reproduction from their receiver rather than long-distance reception, and who at the same time need a good amplifier for record reproduction. The set therefore consists basically of a high-quality push-pull triode amplifier, in front of which is a special tuner, for the broadcast band only, and possessing two-point selectivity, so as to take full advantage on radio of the excellence of the amplifier.

INTRODUCTORY

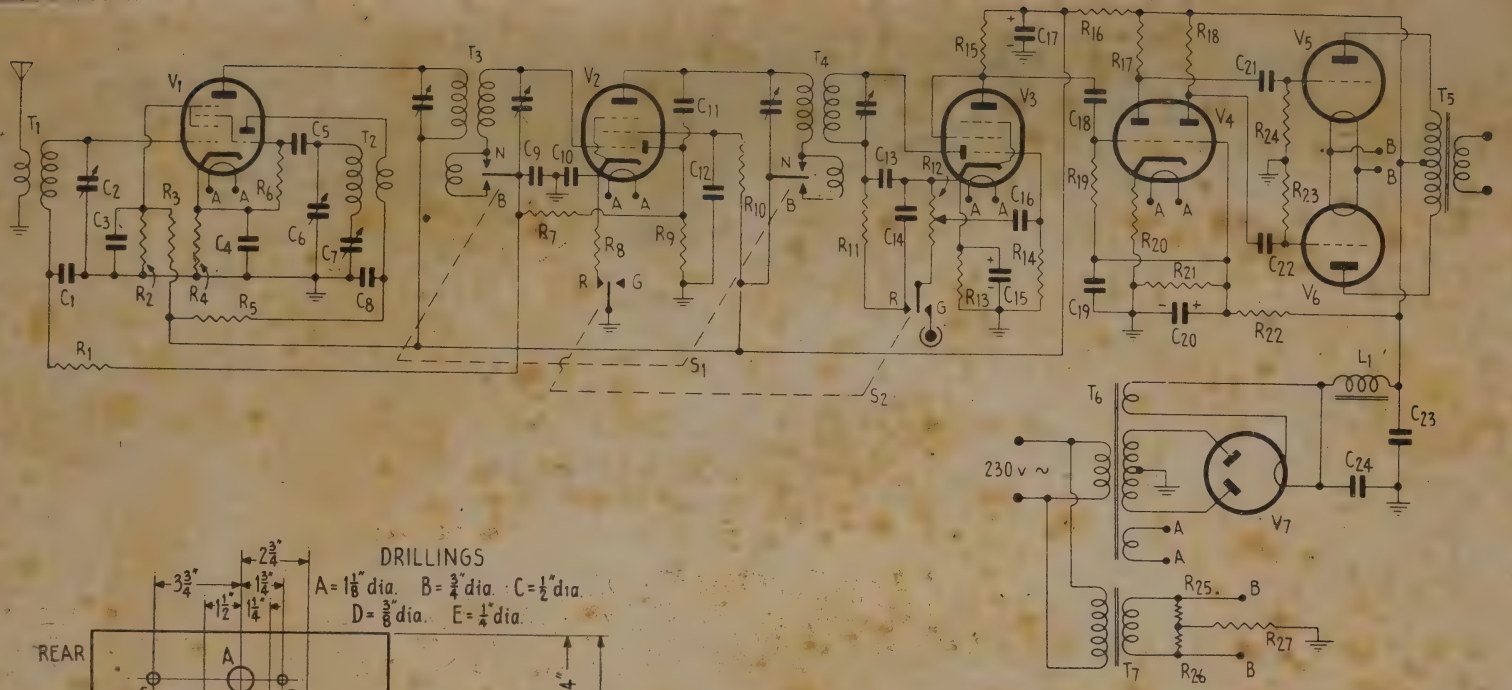
As readers will have realized who have read our recent article entitled "An Idea for a High-fidelity Tuner," the problems to be faced in attempting to realize as good quality from a radio receiver as can easily be got from a good gramophone record are, in the words of Damon Runyon, "more than somewhat." Mentioned in that article was the scheme of using a superheterodyne circuit which embodies variable selectivity in the I.F. channel. It has many forms, and its main divisions are into continuously variable and switched systems. The former is a very difficult matter to design and construct, and, as far as is known, occurs only in one American receiver which is definitely in the high-price class. A large number of receivers have been put on the market (but not in New Zealand) with two or three-point switches giving two or three specific degrees of selectivity, but even these are very rare compared with the number of designs which make no attempt to use variable selectivity, and are still in the expensive class. Also, so far as is known, no set has ever been described in a New Zealand radio publication which has this excellent feature, so that amateur constructors, too, have been unable to do anything about a set of this kind.

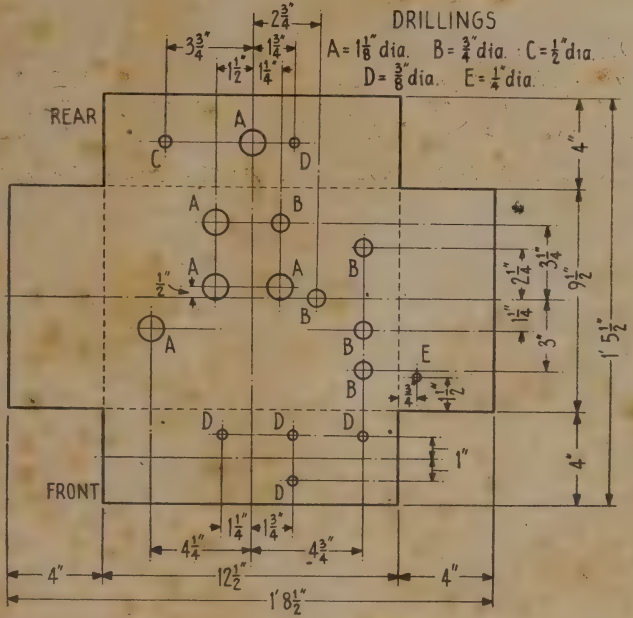
It is true that a two-point selectivity system is not a complete answer to the problem, but, even so, it represents a great advance over the conventional set, and particularly if the "broad" position really is broad, it can give excellent results, such as can only be approached by those of a specially designed local-station tuner, which, although it may fulfil its purpose admirably, yet fails to give anything but local reception! The two-point system, used in this set, gives the degree of selectivity normally associated with the usual types of broadcast receiver when in the "narrow" position, but has a much wider pass-band than usual when switched to the "broad" position. This means that on local stations, where there is an abundantly strong signal, easily overriding any noise that may be about, the high-note response of the tuner is considerably better than that of the average broadcast set, with resultant high-quality reception from these stations. On the other hand, when the station to be received does not put in a strong enough signal to allow the full bandwidth to be used, because of the relatively strong local noise, the set can give excellent reception with the switch in the "narrow" position, because now it has similar selectivity characteristics to any normal set, i.e., too narrow for really good high-note response, but narrow enough to cut out a lot of the high-pitched noise that is received from distant stations if the received band is widened.

THE CIRCUIT ARRANGEMENT

Since the set was to be designed for average-to-good performance on distant stations, and for much better-than-average reception of local stations, there seemed little point in incorporating a tuned R.F. stage. In general, the sensitivity of the average well-built five-valve set is quite adequate on the broadcast band, and unless a set is to be used primarily for DX reception, or else is intended for a locality where there are virtually no local stations, an R.F. stage is somewhat of a luxury. This does not apply, of course, when the receiver has shortwave bands as well, but this one has not, as it was felt that, in order to make the cost-for-performance a reasonable one, shortwave reception was a feature that could well be dispensed with, especially as an expensive set, if it has shortwave bands at all, should have more sensitivity than the average five-valve circuit. Accordingly, the set has been made broadcast only, and with the oscillator-mixer stage as the first valve.

There has been much written in these pages on the subject of signal-to-noise ratio, and on low-noise circuits, not only for high frequencies, but for the broadcast band also. However, readers should not on that account be surprised if in this case we revert to the use of a triode-hexode for the oscillator-mixer, rather than the infinite-impedance mixer that has been featured so many times. Our reason for doing so is that, here again, signal-to-noise ratio need not be given over much consideration in a receiver that is not particularly sensitive, and which is not intended for DX listening. The fact is that, **under most conditions**, the usable sensitivity of a broadcast set is limited by the noise which comes in via the aerial rather than by that generated within the set itself. The exceptions to this statement do not concern us here, since they occur only when the best possible reception is wanted of the weakest possible signals. Thus, there is no point in designing a tuner section of the set to have a specially good signal ratio. On the other hand, the R.F. section of the set can do with all the gain that a normal type of mixer valve can produce, owing to the already-decided omission of an R.F. stage. Thus, we have used the new rimlock triode-hexode, the ECH41, in this position in the set. Its circuit is ordinary in all respects and needs no special comment here. Most of the interest in the R.F. portion of the set is centred in the method used for getting the variable selectivity, and in the use of rimlock valves for both the whole of the signal section, and also for the first audio stage, which also incorporates the second detector diode. The variable selectivity is obtained by the method of switching into circuit small tertiary windings, one on each I.F. transformer. These are arranged to have no effect at all in the narrow position, when the I.F. transformers behave just as any ordinary ones do. The transformers may be purchased ready made, with the tertiary windings set in position, and so the only extra component that has to be provided in order to work the system is the two-pole two-position switch which operates the control. A great advantage of this kind of selectivity





COMPONENT LIST

C_1, C_8, C_9, C_{12}, C_{16}, 0.05 μf.
C_2, C_6, gang condenser.
C_3, C_4, C_{10}, C_{19}, 0.1 μf.
C_5, C_{11}, 50 μμf. mica.
C_7, 600 μμf. padder.
C_{13}, C_{14}, 100 μμf. mica.
C_{15}, 25 μf. 25v. electro.
C_{17}, C_{20}, 8 μf. 450v. electro.
C_{18}, C_{21}, C_{22}, 0.25 μf.
C_{23}, C_{24}, 16 μf. 450v. electro.
R_1, R_{10}, R_{15}, R_{17}, R_{18}, 100k.
R_2, R_5, 30k.
R_3, R_{20}, R_{21}, 35k. 1 watt.
R_4, 200ω.
R_6, R_{11}, R_{16}, R_{22}, 50k.
R_7, R_9, 1 meg.
R_8, 300ω.
R_{12}, 500k. pot.
R_{13}, 1200ω.
R_{14}, 500k.
R_{19}, R_{23}, R_{24}, 250k.
R_{25} + R_{26}, 50ω. C.T.
R_{27}, 750ω 10-watt w-w.
T_1, aerial coil.
T_2, osc. coil.
T_3, T_4, I.F. transformer.
T_5, output transformer, 5000ω to V.C.
T_6, 280-0-280v. 100 ma., 5v. 2a., 6.3v. 4a.
T_7, filament transformer, 6.3v. 3 amp.
S_1, 2-bank, 2-pos. wafer (separate wafers).
S_2, 2-bank, 2-pos. wafer (both banks on same wafer).
V_1, ECH41
V_2, V_3, EAF41 V_4, 6N7
V_5, V_6, 6A3 V_7, 80
L_1, 100 ma. smoothing choke

control is that there are no adjustments to be made when the switch is in the "broad" position. The I.F. amplifier is aligned in exactly the usual way with the switch on "narrow," after which the performance on "broad" is automatically correct. In other words, the success of the system does not depend in any way on critical adjustments which need special equipment for their making. In a set intended particularly for amateur constructors, this is a very important thing.

The circuit arrangement in the I.F. stage and first audio stage, with which are associated the A.V.C. rectifier and second detector respectively, is exactly similar to the same stages of the five-valve rimlock dual-wave receiver described in last month's issue of "Radio and Electronics." The tubes V_2 and V_3 are both EAF41's. V_2 acts as I.F. amplifier and A.V.C. rectifier, while V_3 is the second detector and first audio tube. Advantage is taken here of the good grouping of the circuit functions given by this arrangement, because in this set a good lay-out in this part of the set is more important than usual. The reason is that here provision has to be made for fitting a pick-up input socket, and for cutting out radio reception when the radio/gram switch is in the "gram." position. It will be seen when we come to discuss the lay-out of parts in the set that this line-up of tube functions is a very decided advantange.

The second EAF41, V_3, is connected as a triode, since the high gain of a resistance-coupled pentode stage is neither desirable nor necessary. As a triode, the stage has a gain of more than twenty times, which, in consideration of the gain of the phase-inverter stage, is sufficient.

The phase inverter is a 6N7, V_4 on the circuit diagram, which is used in the cathode-coupled arrangement first presented in these pages in the New Triode Amplifier published in our June, 1948, issue. Of course, the mixing feature has been omitted, as there is no necessity for it in a receiver. Otherwise the circuit of this stage is identical with the one used in that amplifier.

The output stage consists of a pair of 6A3's in push-pull. These are applied under their self-biased 10 watts output condition, and a separate output transformer, much larger than those ordinarily provided with small loudspeakers, is mounted on the chassis. It can be seen in the photograph immediately in front of the 6A3's, behind the dial. It is a transformer designed for public address work, and not intended to give a high-fidelity type of response curve. It has been used here because its rated power handling ability is 20 watts. If the power it has to handle is limited, as here, this transformer shows up very much better on tests than when it is handling its 20 watts, and at the lower levels at which a domestic set is usually run, it can almost be called a high-fidelity transformer—at least by comparison with the minute speaker transformers that are standard equipment in commercial sets. Its use is therefore very well justified, on the score that, with it, the builder is getting good performance at a lower price than would be paid if a 10-watt high-fidelity transformer were used. Of course, this should not be taken to mean that the man who can afford a much better output transformer should not do so, for the general quality of the set is such that the extra expense is well justified if it can be borne. At the same time, we would like to stress that a high-fidelity output transformer is a definite waste of money if one is going to use only an "ordinary" eight-inch speaker. We strongly recommend intending builders to invest in one of the better-quality 12-inch speakers and a high-fidelity output transformer if their pockets will run to the expense. Even without these items, the set will give better than average reproduction, both on radio and from records.

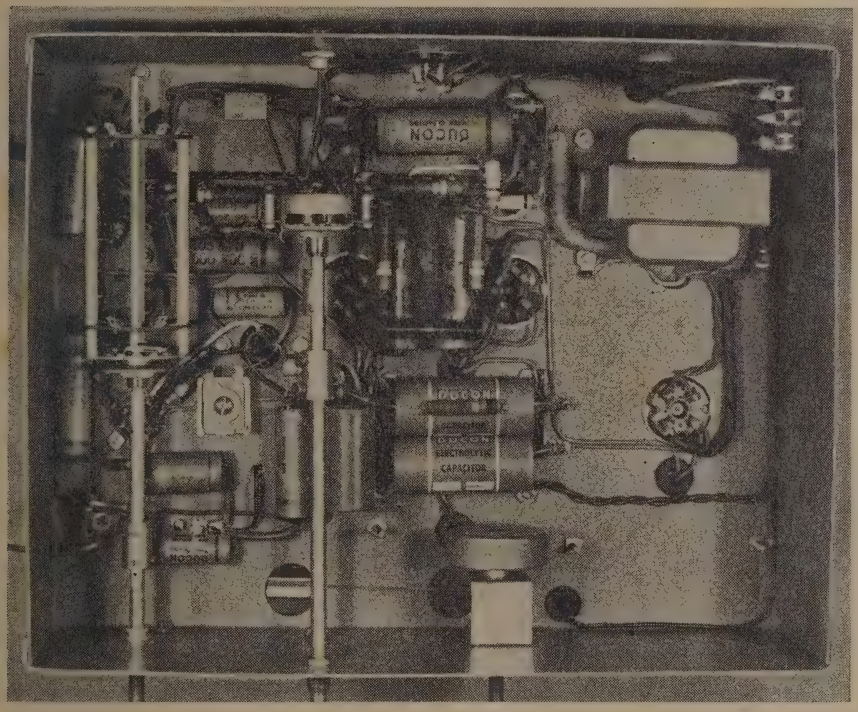
The power supply is quite normal, and uses an 80 rectifier. We have specified a separate filament transformer for the 6A3 output valves, but there is no reason why an extra winding cannot be used on the main power transformer if desired. It is a moot point whether the separate filament transformer is more or less expensive than having a special power transformer built with two .3v. windings, and constructors can please themselves which method is used. By the same token, there is no reason why 2A3's should not be used instead of the 6A3's if they are wanted to suit an existing power transformer which has a 6.3v. and a 2.5v. filament winding. The valves are identical electrically except for the filament voltage and current.

DETAIL OF THE CIRCUIT

Starting at the aerial terminal and working through the set, we come to no unusual features before the I.F. amplifier is reached. The ECH41 oscillator-mixer valve has the usual circuit, in which the oscillator has a tuned grid circuit and the usual padding and trimming arrangements. The trimmers have not been shown, since in a single-band receiver such as this they are mounted as part of the gang condenser. The oscillator plate dropping resistor ensures that too high an oscillator voltage is not applied to the mixer section, and that too many D.C. volts are not placed on the oscillator plate. The hexode screen-grid is fed, as recommended by the manufacturers, by a voltage divider rather than a dropping resistor. This is specially important in a set without an R.F. stage, because it gives the mixer its most effective control under A.V.C.

Coming now to the I.F. amplifier, we see that, apart from the "new look" given the circuit by the variable selectivity I.F. transformers, this, too, is not at all out of the ordinary It is well known that the only way of varying the selectivity of a stage using double-tuned transformers as coupling elements, in such a way that the system remains tuned to the same centre frequency as it possesses in the "narrow" position, is to use as the control a variation in the mutual inductive coupling between the windings. If attempts are made to over-couple the windings in each transformer by the addition of direct capacitative or inductive coupling, one gets the extra bandwidth that is wanted, but at the same time the response curve is shifted so that the centre frequency of the curve no longer remains where it was when the circuits were tuned up and coupled for the narrowest pass-band that is needed. According to the exact type of additional coupling employed, the centre frequency moves off either higher or lower in frequency than the original one. In practice, this behaviour cannot be tolerated, because it would mean that after the selectivity switch had been altered, it would be necessary each time to readjust the tuning of the receiver. The difficulty is that, in order to vary the mutual inductive coupling between the windings, they must be moved closer together or farther apart. This introduces difficulties in the mechanical design of the I.F. transformers, and also makes them very expensive compared with the

normal types with no selectivity variation. It was for this reason that the tertiary winding scheme was developed. As can be seen from the circuit diagram, there is a small third winding in each transformer. This winding is arranged so that in the "narrow" position of the Narrow/Broad switch, it is out of circuit altogether, one end being connected to the low-potential end of either the primary or secondary, and the other end being free. In the "broad" position, the tuning condenser of the transformer is switched so that the extra winding is placed in series with the secondary, in the case of T_3, and the primary, in the case of T_4. Now, the main effect of this is to increase the coupling between the two windings of the transformers. This



Under-chassis view of the receiver.

is because the third windings consist of only a few turns, closely coupled to the windings to which they are not connected. It is clear from an examination of the circuit that in the case of T_3 the secondary winding must be detuned a little, since the third winding, in addition to increasing the coupling, also adds a small amount of extra inductance in series with the secondary. Fortunately, however, the effect on the coupling is much greater than the effect in the secondary inductance, so that, although there certainly is a small amount of detuning, this is so slight as to be negligible. By this means the pass-band of the I.F. amplifier is widened without appreciable shift in the centre frequency to which the I.F. transformers are tuned. A refinement worth noting is the way in which the secondary of T_3 is connected to the tertiary, while in the case of T_4 the tertiary is attached to the primary. As far as the final result is concerned, it makes no difference which way round the connection is made; T_4 has the disadvantage that the switch contacts are at H.T. potential, but 250v. is not high enough to worry the ordinary wafer type of switch that should be used here. Also, there is no appreciable voltage drop in the tertiary winding, so that there is no annoying thump when the switch is operated. In the event that the tertiary were connected to the secondary in T_4, the switch would break and make the D.C. circuit of the second detector diode, and this would certainly result in a loud thump in the speaker. This is the reason for the difference between the two transformers.

In using these special I.F. transformers, it should be noted that the switch is not provided with them, and that a wafer type, similar to those used as wave-change switches, is employed This is because wafer switches have very low capacities between the contacts and earth, which is definitely not the case with most toggle or other types that might conceivably be used. If a high-capacity switch were used here, the result would be unpredictable, in that the stray capacities would tend both to detune the circuits and to cause the coupling to differ from what was intended by the designer of the transformers. Intending builders should note how we have placed the wafers of the switch directly under the I.F. transformers, and made the leads in the switching circuit as short as possible.

The next point of interest is the Radio/Gram switch. This also uses a low-capacity switch, as a help in preventing audio voltages from "jumping" the contacts via the inter-contact capacities. Should this occur (but it will not if this type of switch is used), the effect is that of break-through of the audio signal from the tuner section of the set when the switch is in the "Gram" position. In order to make assurance doubly sure, and to prevent any possibility at all of radio break-through, a two-pole two-position switch has been used in the Radio/Gram switch; the second bank is used to break the cathode circuit of the I.F. amplifier. This scheme is very effective, and in the prototype it was possible to turn to Gram., and then turn the volume control full on without the slightest trace of signal from the tuner. The cathode bypass condenser of V_2 is connected right at the valve socket, and only the earthy end of the cathode resistor is switched. Also, the detector coupling and bypassing is automatically disconnected in the Gram. position, so as not to cause any loss of high audio frequencies from the pick-up.

Since the audio amplifier circuit was fully described in the June issue of this journal, there is little necessity to enlarge upon it further. The only significant circuit difference between the amplifier described there and the one used in this set is the fact that the former used the 6N7 phase inverter as the first stage, which was followed by a second

6N7 as a push-pull driver stage. Here, the phase inverter circuit drives the output tubes directly, and is preceded by the triode-connected pentode section of the second EAF41, V_3. This makes a really excellent audio end for any receiver, and has ample voltage gain for most of the common types of pick-up. If the builder wishes to use one of the low-output moving coil pick-ups, it will be necessary to use a self-contained pre-amplifier, as there is not enough room on the chassis for the extra valve, nor is it very desirable to put such a stage on the main chassis in any case. Some months ago, we published a circuit giving amplification and low-frequency compensation suitable for a moving-coil pick-up, and employing a 6SN7. This can be built as a very compact separate unit, completely shielded, and mounted under the motor-board, close to the pick-up. It could receive its power from the main chassis, as the requirement is very small.

CONSTRUCTIONAL DETAILS

Our cover this month gives a general view of the top-chassis arrangement of the set, and this will help in laying out the parts on the chassis, for which the working diagram includes only the large holes, since most constructors prefer to do the actual mounting of the main components themselves. The large under-chassis view should be a good and sufficient guide to the underneath lay-out. One point that will probably strike the reader is the way in which all controls except the tuning spinner are operated from extension shafts. This gives very little trouble, as it entails only the construction of two small brackets, and the use of old volume control bushes as bearings for the quarter-inch extension shafts. The shaft couplings can be bought at almost any shop that specializes in radio components. The trouble of mounting the volume control potentiometer, the selectivity switch, and the Radio/Gram switch at a distance from the front of the chassis instead of on it, is amply repaid by the short, direct wiring it makes possible, and therefore by the lack of certain troubles which can occur if long leads have to be used in the parts of the circuit concerned. If we had to retain the usual positions on the front of the set for the controls, it would have been very difficult, if not impossible, to make such a good lay-out of the circuit as a whole. The leads in the pick-up input and second detector circuit are very short, which is quite important in a set like this, where there is a fairly high-gain audio section. Long leads here can cause the pick-up of hum and, worse, of R.F. voltage; both of these must be at a minimum in a receiver which pretends to any sort of quality, and this one does! R.F. in the audio section can be a very annoying source of regeneration, and, if this is present, even in the smallest degree, the variable selectivity will in all probability turn out to give no variation in selectivity at all. In addition, the bandwidth of the set will be less than that of one which does not set out to obtain much of this commodity anyway, but which is quite stable. As well as instability, R.F. in the audio can ruin the audio amplifier's characteristics in no uncertain manner. The trouble is one of valve overloading which occurs before full audio output, owing to the fact that the total signal applied to the valves is audio **plus** R.F., the latter having no useful effect. The mounting of the selectivity switch has already been mentioned. It is clearly most important to have short leads here, because long straggling ones could easily cause regeneration in the I.F. stage, with the unfortunate results mentioned above.

The ECH41 is the valve at the front right-hand corner of the chassis, and the circuit follows logically in a straight line down to the right-hand side of the set. Directly behind V_1 is T_3, the first I.F. transformer. Behind this again are the I.F. amplifier, V_2 and the second I.F. transformer, T_4. The latter is right at the back right-hand corner of the chassis. To the left from here, and somewhat to the front, are the remaining four valves of the receiver proper, arranged at the corners of a square. The two front holes of these four are taken up by the 6A3 sockets. The one at the back to the left is the 6N7, and the remaining one is the second EAF41, V_3. Now, referring to the under-chassis view, it can be seen that the bracket holding the volume control potentiometer and the Radio/Gram switch comes a little in front of the V_3 socket, and slightly to the left, looking from underneath.

The smoothing choke is indistinguishable externally from the 6A3 filament transformer, but the latter is the one mounted under the chassis, while the former is to be seen in the top view, at the front left-hand corner, close to the rectifier valve. There is not very much that can be said about the lay-out of small parts underneath the set, except that they are arranged so as to give the shortest possible leads. This is more important in the R.F. part of the circuit than any other, and is not difficult to arrange. The coils are of the shielded type, and chassis holes are provided so that the connecting lugs can project through, forming tie-points for the wiring and for some of the resistors and condensers. For example, the plate winding of the oscillator coil is connected, one end to the oscillator plate and the other to the dropping resistor and bypass condenser. The coil lug therefore forms a convenient tie-point for these two components. The condenser is taken to a suitable earth point, and a second tie-point has to be provided for the H.T. end of the dropping resistor. In the I.F. circuit, the switch contacts form useful tie-points also, and as long as the fullest use is made of such ready-made connecting places, the circuit will take shape of its own accord, and the number of parts for which it is necessary to provide terminal strips will be a minimum. In the audio end of the circuit, one can use point-to-point wiring, if desired, or one can make use partly of the valve pins and partly of terminal strip for giving tie-points that cannot be made on the valve sockets.

ALIGNMENT

In a set of this nature, it is most important that the alignment is properly carried out. This applies more to the I.F. stage than anything else, for the worst that can happen if the signal and oscillator circuits are not quite "on the knocker" is a certain loss of sensitivity. The I.F. channel, however, controls the selectivity and thence the audio fidelity, and, since we have been at pains to incorporate variable selectivity, one of the best features of the receiver will not be properly exploited if the I.F. stage is improperly aligned. Luckily, the special I.F. transformers do not require any special treatment in this respect, as all that has to be done is to align them "on the nose" with the switch in the "narrow" position. Thereafter, the shape of the response curve is decided, in the "broad" position, by the transformers, over which the constructor has no control. The above statement is intended to impress

builders that, unless they have a signal generator themselves, or else take the receiver to someone who has one to have the I.F. transformers properly aligned, they cannot be certain that the performance of the I.F. stage in the "broad" position will be according to expectations.

Even when alignment is carried out with a signal generator and output meter, it is necessary to take more care than usual to see that each trimmer is peaked exactly. If it is not, then there may not be as much difference as there should between the results obtained in the two positions of the selectivity switch. However, intending builders need have no fear that if these instructions are properly carried out, the set will not come up to expectations. In order to test this, on the prototype set built in our own laboratory, we lined the set up by the ordinary signal-generator and output meter method, and then, without touching any of the adjustments, examined the I.F. response curves on both selectivity positions by means of a frequency-modulated oscillator and oscilloscope. This test showed that the best adjustment had been found by the ordinary method, indicating that, although the wobbulator method is very quick and convenient for lining up a set of this kind, it is by no means essential, and that the required result can easily be obtained by normal alignment methods. It may also be mentioned that the selectivity of the signal input stage is not great enough to modify the response curve of the I.F. amplifier to any noticeable extent. This was shown by examining the response curve on the 'scope both at I.F. and at signal frequency, with the whole of the set working normally. This, by the way, was one of the reasons for omitting an R.F. stage, for even a single one has more chance of losing some of the bandwidth of the special I.F. system, because of its own selectivity, which is automatically added to that of the I.F. amplifier.

The alignment of the signal and oscillator circuits are exactly similar to that of any superhet. not employing an R.F. stage. Once the I.F. amplifier has been aligned, the selectivity switch is put in the "narrow" position, and the aerial and oscillator trimmers, and the oscillator padder, are adjusted in the ordinary way.

OPERATION OF THE RECEIVER

It will have been noticed that this receiver does not incorporate the usual type of tone control. This has been purposely left out so as not to complicate the issue. The selectivity switch replaces the tone control, and is used in its stead. Normally, the switch will be used in the "broad" position only on local and strong distant stations. In order to get the best out of the wide pass-band, it is necessary to tune the set accurately. This should be done with the selectivity switch in "narrow," because it is difficult to find the correct tuning in the other position. After the set has been accurately tuned in, the selectivity switch is turned to "broad." It will be found that the position of the switch makes little or no difference to the volume level, so that it is not necessary to readjust the volume control after switching to "broad." If one is tuned to a more distant station, on which there is appreciable noise from atmospherics or other interference, it will be found that the best results are got with the set in

(Concluded on page 48.)

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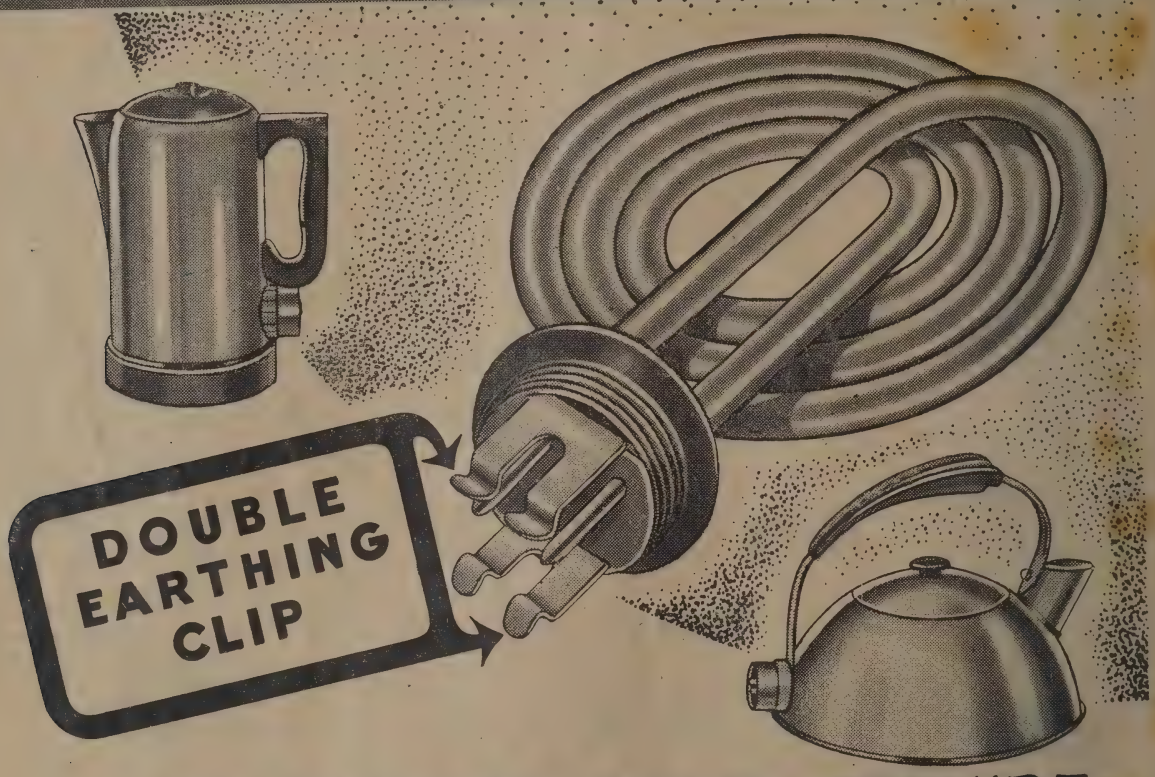

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Some Tested Circuits for 807's as Audio Amplifiers

The 807 seems to be regarded by many as suitable only for power outputs of 50 watts and more when used as a push-pull audio amplifier. In order to demonstrate that this view is not correct, we have performed some experiments, and as a result have developed a number of circuits in which the tube demonstrates its worth for powers ranging from 10 to 20 watts and for the highest quality. These powers are realized with very modest H.T. power requirements, and should be of much interest to gramophone enthusiasts, public address workers, and amateur transmitters alike.

Since the publication not so long ago in the "Wireless World" of Mr. Williamson's high-fidelity amplifier, which used KT66 beam-tubes as triodes with a large degree of negative feedback, there has been a very great amount of interest in this class of amplifier. This interest has not been based simply on theoretical grounds, but mostly on really outstanding practical performance. It has been found, for instance, that, contrary to the accepted idea, an amplifier whose distortion is in the region of 0.1 per cent. rather than 2 to 3 per cent., which has hitherto been regarded as the lowest that is detectable by ear, really does sound different. It appears, therefore, that the ear finds difficulty in distinguishing between, say, 2 per cent. and 5 per cent. distortion, but can quite readily tell the difference between 2 per cent. and 0.1 per cent. What does not seem to have been fully realized is the fundamental principle by means of which Mr. Williamson has achieved his desirable result, and thereby demonstrated a new fact in relation to high-fidelity reproduction.

BASIC PRINCIPLE OF THE "WIRELESS WORLD" AMPLIFIER

Since anyone who is interested in quality reproduction is inherently given to examining circuits of different types, and to evaluating their worth by comparison with other circuits which purport to have good features, it is not altogether surprising if some such enthusiasts have missed the point that is basically responsible for the superior performance of Mr. Williamson's amplifier. It cannot be found by a simple examination of the circuit, which, apart from an obvious concern about balancing the push-pull part with great care, is not particularly unusual to look at. The key is to be found in the fact that the negative feedback used amounts to as much as 20 to 30 db. Now, this is a relatively enormous amount of feedback, especially when it is realized that it is connected from the secondary of the output transformer back to the cathode of the first stage of the amplifier. The fedback loop therefore includes virtually the whole of the amplifier, and its distortion, whether generated in the voltage amplifying stages, the power output stage, or the output transformer, is beneficially affected in proportion to the amount of feedback that is used. Now there is nothing new in this, as a principle. Similar types of amplifiers have been suggested almost as long as there has been negative feedback. The question is: why has it taken so long for an amplifier to be designed which can use as much feedback as this one does, without introducing difficulties for the constructor?

The answer is to be found in the fact that, although the benefits of negative feedback are well known, and although it is common knowledge that the greater the degree of feedback the greater the benefits conferred by it, a grave practical difficulty occurs when large amounts of feedback are attempted, and especially over a number of stages. It is this—that, unless suitable precautions are taken (and these are not always easy to apply), the feedback does not remain **negative** at all frequencies. It can become zero and can even change itself round and become positive feedback. When this happens, it is largely a matter of luck whether or not the amplifier breaks into oscillation—a far from desirable result!

To enlarge upon this a little further, it can readily been seen why this situation can arise. For the feedback to be absolutely negative, it must be 180 degrees out of phase with the signal voltage at the point where the feedback is applied. This is easily obtained in the middle frequency range, because here the only phase shift caused by the amplifier circuit is the 180-degree phase change per stage which occurs because of the way in which the valve works. However, at low and high frequencies, the phase shift per stages becomes greater or less than 180 degrees. In a single stage, this does not matter so very much, because the phase shift cannot exceed 90 degrees, with the result that the feedback can never become positive, though it can reduce itself to zero. This means that, at the frequency at which this occurs, there is no feedback, and so there is no reduction of amplifier gain. The response curve of the amplifier therefore rises sharply at high and low frequencies, and exhibits a peak at some frequency in both the high and low range at which the feedback has been reduced to zero by the phase shift. At the peaks, the gain of the amplifier may not be as high as the mid-frequency gain without feedback, because the peaks may, and in all probability will, occur at frequencies where the gain without feedback has decreased in the normal course of events.

The situation above has been used to illustrate what happens when feedback is applied round one stage only. If it is applied round two stages, however, it is possible for the feedback voltage to lag or lead by a maximum of 180 degrees. This makes it possible for the feedback not only to reduce to zero, but even to become positive in sign. This is another way of saying that the amplifier is now **regenerative**, and so can oscillate, if the gain is great enough at the frequencies where regeneration occurs. Similarly, the situation is even more difficult when the feedback is applied over three or four stages. The more stages are included in the feedback loop, the smaller the phase shift PER STAGE that is needed to turn the feedback from negative to positive. Also, the greater is the likelihood of there being enough gain for oscillation at the frequency where positive feedback occurs.

The above considerations lead to two simple conclusions regarding feedback amplifiers:

(1) The more stages are included in the feedback loop, the less the phase shift per stage that can be tolerated.

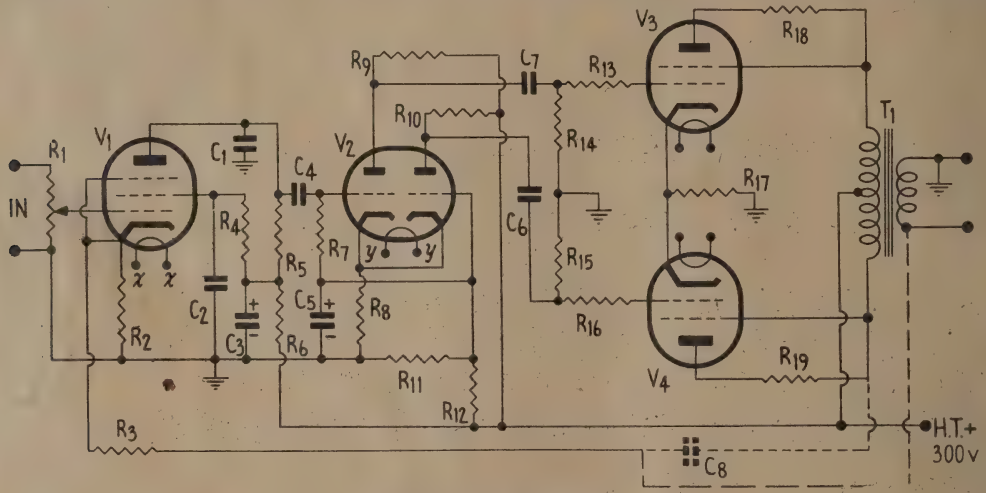
(2) For a given number of stages within the feedback loop, the less the phase shift, the more feedback can be used without danger of instability.

The two points stated above are really different ways of stating the same fact, and the second one gives the key to the success of the "Wireless World" amplifier designed by Mr. Williamson. Thus, what he has done is to design a circuit (including output transformer) which has very much less phase shift than the usual three-stage amplifier. As a result, he has found it possible to apply 20 to 30 db. of feedback and thereby to reduce the circuit distortion by a similar degree. Suppose, for example, that the circuit distortion without any feedback is 2.5 per cent. at full output, this means that the distortion with feedback applied will be reduced to 0.1 to 0.25 per cent. at full output, and to correspondingly smaller figures at lower outputs.

We have therefore developed a basic circuit for using 807's in the output stage, with almost as much feedback as is used in the Williamson amplifier, and either as triodes or as tetrodes. These circuits are presented below.

POWER OUTPUT CONSIDERATIONS

The first circuit to be described is one in which the 807's are connected as triodes and with an H.T. supply of 300 volts at 100 ma. This arrangement gives a measured power output of 10.7 watts, and enables 16.25 db. of feedback to be used, either from the secondary of the output transformer or from one plate of the output stage, back to the cathode of the first stage. This figure is not quite as high as that quoted for the "Wireless World" amplifier, but, even so, it is much greater than the amounts of feedback usually seen in amplifiers of this nature, and is great enough to reduce amplifier distortion to



COMPONENT LIST

R_1, 1 meg. pot.
R_2, 1600ω.
R_3, 250k. (min.) (see text).
R_4, R_7, 250k.
R_5, R_9, R_{13}, R_{16}, 100k.
R_6, R_{11}, 25k.
R_8, 20k.
R_{10}, 120k.
R_{12}, 50k.
R_{14}, R_{15}, 500k.
R_{17}, 275ω 2 watts.
R_{18}, R_{19}, 50ω.
C_1, 100 $\mu\mu$f.
C_2, 0.5 μf.
C_3, C_5, 8 μf. 450v. electro.
C_4, 0.05 μf.
C_6, C_7, 0.1 μf.
C_8, 4 μf. 500v. oil-filled.
V_1, 6J7 or EF37.
V_2, 6SN7.
V_3, V_4, 807.
T_1, 9000ω to voice-coil.

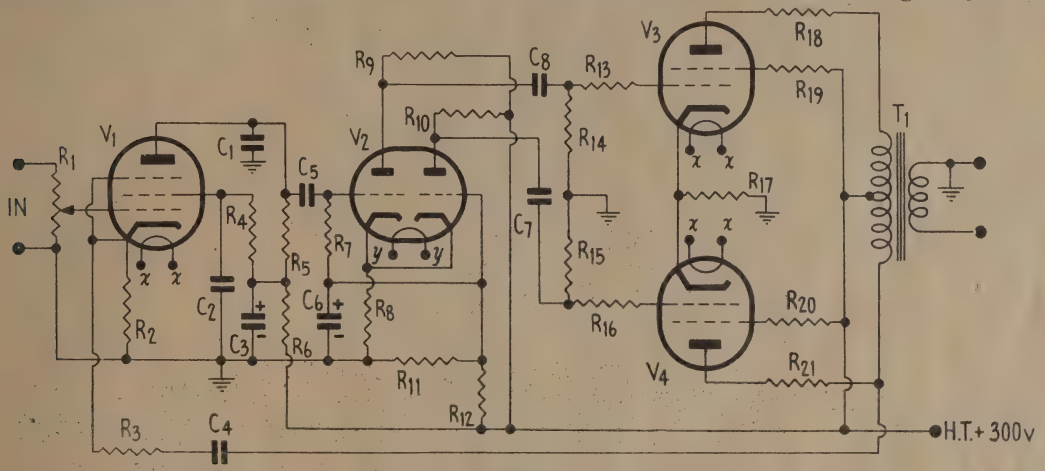
APPLICATION OF THIS PRINCIPLE TO 807 AMPLIFIER CIRCUITS

We have gone to some lengths in illustrating the basic principle underlying the design of the "Wireless World" amplifier, both from the point of view of its general interest and also in order to show that there is nothing mysterious about the "super-excellence," if such it may be termed, of this amplifier. The principle that has been stated shows, among other things, that it is by no means essential to use KT66's. There is no fundamental reason why any other valve which has suitable triode characteristics should not be employed. Nor need an amplifier of the kind we are discussing necessarily use triodes in the output stage. Others, notably Hilliard, in America, have shown that pentodes or beam tubes, with suitable circuits, can and do produce an answer that is at least as good as that given by triodes.

under 0.5 per cent. at all levels smaller than the maximum power output quoted. Readers should not assume, because of the 10.7 watt rating of the circuit, that triode-connected 807's are incapable of giving more output than this. They are; but in designing this amplifier circuit we have done more than simply consider the greatest possible power output. In fact, a large number of our readers, we are convinced, will not want an amplifier with a higher output than this. It is, to our way of thinking, about the ideal size of amplifier for home use, in that more than 10 watts can rarely be made use of fully, owing to the small size of the room in which it has to work. At the same time, 10 watts is ample power, even for a large room. This being the case, the limitation of the power of the triode amplifier to 10 watts enables the H. T. power supply to be cut down, both in voltage and current. Three hundred volts at 100 ma. is not large enough to be too expensive for the

average constructor, and represents a real economy over what would be needed to give the amplifier a power output of 20 or even 15 watts. Also, the supply is not a difficult one to build, because the current drain at full output is only a few milliamps more than at no signal. The regulation of the supply is therefore quite unimportant, and costly low-resistance chokes are not needed.

To take care of those who have a real need for a high-fidelity amplifier with up to 22½ watts, we have re-arranged the circuit as shown in Fig. 2. This time the 807's are used as tetrodes, the maximum feedback is 17.5 db., and the power input is 22.25 watts, maximum undistorted. And by "undistorted" we do not mean 5 per cent.!



COMPONENT LIST

R_1, 1 meg. pot.
R_2, 1600ω.
R_3, 250k. min. (see text).
R_4, R_7, 250k.
R_5, R_9, R_{13}, R_{16}, 100k.
R_6, R_{11}, 25k.
R_{10}, 120k. (see text).
R_{12}, 50k.
R_{14}, R_{15}, 500k.
R_{17}, 120ω 2 watts.
R_{18}, R_{19}, R_{20}, R_{21}, 50ω.
R_8, 20k.
V_1, 6J7 or EF37.
V_2, 6SN7. V_3, V_4, 807.
T_1, 4750ω to voice-coil.
C_1, 100 μμf. C_2, 0.5 μf.
C_3, C_5, 8 μf. 450v. electro.
C_4, 0.05 μf. C_6, C_7, 0.1 μf.
C_8, 4 μf. 500v. oil-filled.

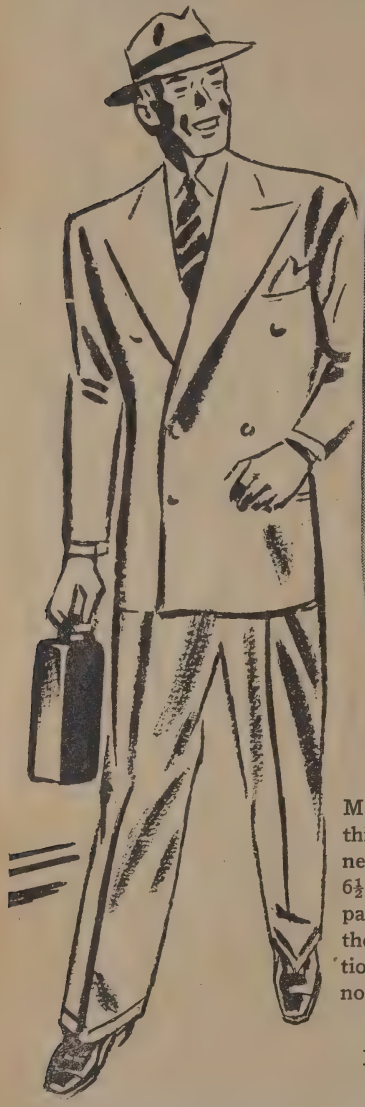
The H. T. requirements for the second amplifier are only 300 volts at 150 ma., which is a 50 per cent. increase in D.C. input power for an increase in output power of more than 100 per cent. This is the main advantage of the tetrode connection, since beam tetrodes are more efficient than triodes as power converters. The 22.25 watts given by this amplifier are enough to 100 per cent. modulate a 100-watt carrier, using cathode modulation!

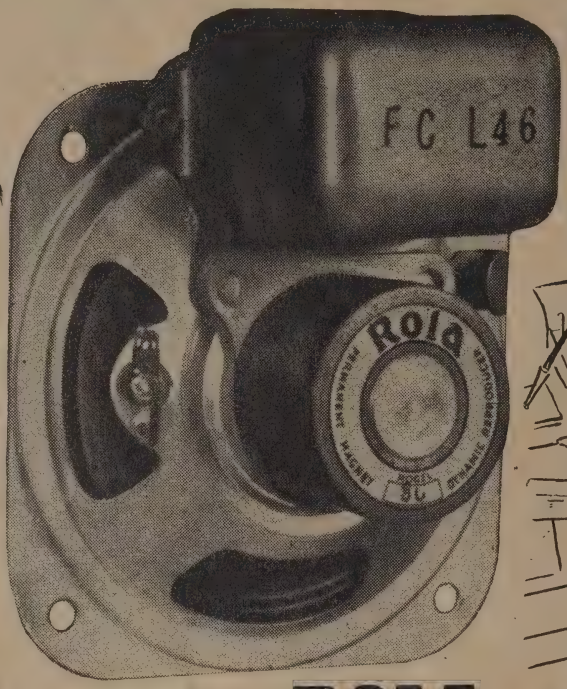
VOLTAGE AMPLIFIER CIRCUITS

A glance at Figs. 1 and 2 will show that the voltage amplifying sections of both amplifiers are substantially identical. Comparing the results, as so far presented, with those of the "Wireless World" amplifier, we find that the ones described in this article are not capable of taking quite so much feedback as the former. However, we do not take a serious view of this, because these circuits use almost as much, and it is unlikely that the results will be noticeably different. In our circuit, we have not gone to the trouble to make the intitial stage direct-coupled to the second stage, which in our case is also the phase inverter. The difference in performance, slight though it is, can be put down mostly to the omission of this direct coupling, particularly in respect to the low-frequency feedback limit. However, we will discuss this point further when we come to talk about the adjustment in practice of the feedback network. The first stage in the amplifier is a pentode voltage amplifier, and uses either a 6J7 or an EF37. The latter tube is specially constructed to be free from microphonic effects, and its use in this position should not be strictly necessary, since the feedback reduces the overall gain of the circuit to the point where the input voltage for full output is 0.75v. for the circuit of Fig. 2, and not very different from this in the circuit of Fig. 1. Used at this input level, there should not be trouble from microphonics unless one is unlucky enough to strike a defective tube. This stage is quite conventional except for the omission of the cathode bypass condenser. This has to be done in order that the feedback voltage can be developed across the cathode resistor. It also helps to reduce distortion in this stage, since it provides a certain amount of degeneration in the tube circuit itself, irrespective of the main feedback connection. The second stage uses a 6SN7 as a cathode-coupled phase-inverter, which has useful gain as well. This circuit has been used a number of times before in these pages, and a fairly full discussion of its operation was given in the issue of June, 1948. By making the common cathode resistor high enough, it is possible, with further precautions, to achieve a well enough balanced output for most purposes. However, in an amplifier which attempts to reach high-fidelity standards, it is desirable to have exact balance between the sides of a push-pull system. The cathode-coupled circuit is capable, with care, of being exactly balanced, and so is admirably suited to our purpose. It is for giving exact balance that the halves of V_2 have been shown with unequal plate loads. The first half (i.e., the section that is fed directly by V_1) has a load resistor of 100k. ohms, while the other half, which does not get quite the same input voltage, has a plate load of

(Continued on page 35.)

ANISOTROPIC ALNICO





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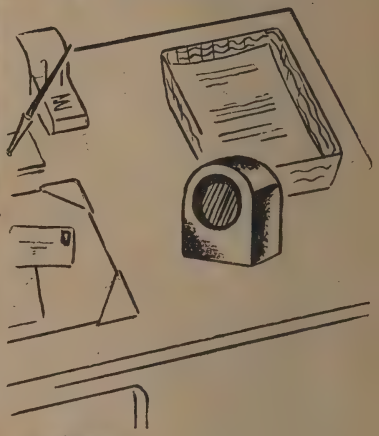

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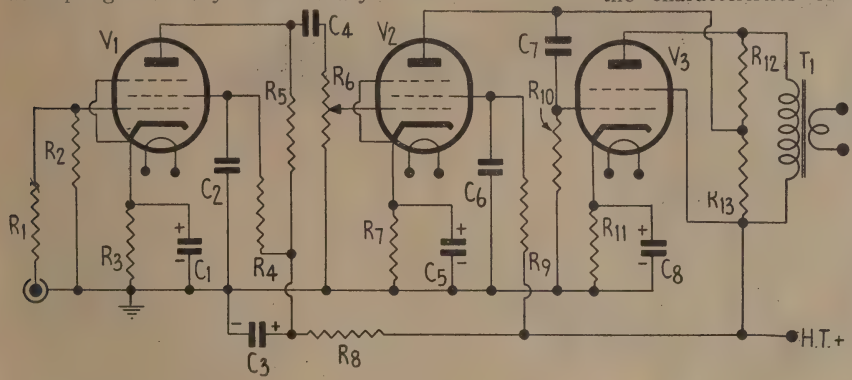
QUESTIONS and ANSWERS

A SMALL AMPLIFIER FOR VIBRATOR OPERATION

I.D.T., Thames, writes as follows: "I would be very pleased if you could supply me with the circuit diagram of a small amplifier suitable for use with a low-level microphone and powered from a vibrator supply. I have in my possession an already built supply with an output of 135v., and would like to use a single 6V6 output stage, preceded by a 6J7 driver and a further 6J7 microphone pre-amplifier. Could you please give details of the H.T. current drawn by the circuit recommended, and whether you would recommend a higher H.T. voltage. I would also appreciate any details about shielding of special decoupling that may be necessary."



COMPONENT LIST

V_1, V_2, 6J7. V_3, 6V6.
R_1, 3 megs. R_2, 2 megs.
R_3, 1500ω.
R_4, R_{12}, 1 meg.
R_5, 250k.
R_6, 500k. pot.
R_7, 750ω.
R_8, 50k.
R_9, R_{10}, 500k.
R_{11}, 250ω.
R_{13}, 100k.
C_1, C_5, 25 μf. 25v. electro.
C_2, C_6, 0.5 meg.
C_3, 8 μf. 250v. electro.
C_4, C_7, 0.1 μf.
T_1, 5000ω. to voice-coil.

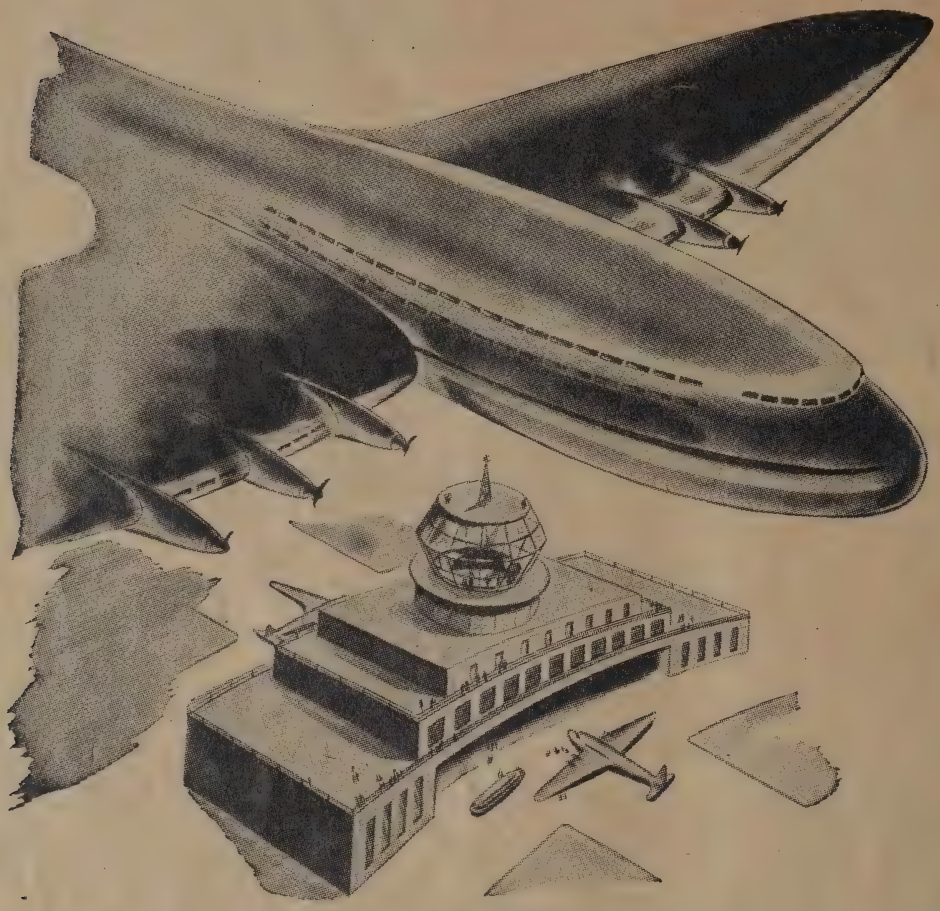
We have pleasure in supplying a circuit that will probably be completely satisfactory for I.D.T.'s purpose. The suggested tube line-up has been used, as this enables a generous degree of negative feedback to be placed round the output stage, resulting in improved quality, and at the same time making use of the high overall gain that is available, instead of simply throwing it away, as it were. An important detail in the circuit is the decoupling filter R_8, C_3, in the plate and screen supply of the first stage. This will be found absolutely essential if motor-boating is to be prevented. Also, the position of the gain control is worthy of note. This is placed between the first and second stages, and not, as is more usual, at the input to the whole amplifier. This has been done because a low-level mike has been specified. This being the case, it is not possible for the first stage to be overloaded; it is therefore of considerable advantage to have the gain control in the grid circuit of the second stage. The reason is that the signal level is about 100 times greater at this point than at the input to the first stage, so that any noise tending to be generated by the volume control when it is moved is much less likely to be noticed, owing to the signal level being higher than that of the noise.

If the control is at the input to the whole amplifier, the control noise is of the same order of magnitude as the signal from the microphone, and so becomes very troublesome, especially if the control has to be adjusted at all frequently. The scheme can be used with success, however, only when the signal into the first stage is so small that even when all of it is fed to the grid without the intervention of a control, it cannot overload the valve.

The circuit has been arranged to use a crystal microphone. This needs a load resistor of the order of 5 megohms or so, but it is not permissible to have a resistance as high as this between the grid and cathode of the valve. The circuit given overcomes this by splitting the 5 meg. load resistor for the microphone into two parts. R_2, which is 2 megs., is in the grid circuit of the first 6J7, and is not high enough to cause trouble. As is apparent from the diagram, only a portion of the total available output voltage of the microphone is applied to the tube, but this is unimportant, as there is ample gain in the circuit to make up for the slight loss. A shielded input connector is recommended, and it should be self-evident that the mike cable needs to be shielded, too. Although a crystal microphone is a very high-impedance device, it is possible to use quite long shielded leads from the mike to the amplifier, because the characteristics of the mike are such that the extra shunt capacity due to the cable does not affect the frequency response to any appreciable extent, but only reduces the output voltage slightly.

The construction of the amplifier can be quite straightforward, and there should be no special problems in connection with shielding, particularly if the amplifier and power supply are built on separate chassis. The sensitive part of the circuit from the point of view of picking up vibrator hash will be the first stage, and it would be a good idea to enclose the whole of this stage in a small box (metal, of course), which is then mounted on the amplifier chassis, preferably with rubber grommets to act as flexible mountings. This will help to prevent trouble from microphonics in the first stage. The shield box can be, say, 2 in. x 3 in. x 3 in. high, and will have plenty of room in it for a sub-chassis, about an inch from the bottom. The socket will be mounted on this sub-chassis, and the small parts can be wired in underneath it in the usual way. In order to keep the input lead to the grid of the first 6J7 as short as possible, the input connector could be mounted on the side of the box, in which case it will not be necessary to shield the inch or so of wire which goes from the connector to the grid-cap.

The power output of the 6V6 will be in the neighbourhood of 1.5 watts, with an H.T. voltage of 135v., but if this is found to be insufficient, a power supply can be made up to give 180v. at about 40 ma., and this will enable a power of 2 watts to be realized. The total H.T. current in either case should be not greater than 40 ma., which should be well within the capability of the supply.



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MORE ON REFLEX BAFFLES

S.S.N., Devonport, Tasmania, writes: "I have read with interest your article by Mr. Whale on doing justice to high-fidelity amplifiers, and, being in the process of building myself a reflex baffle, was rather disturbed to read of 'tubbiness' in connection with these baffles. No other article on this subject that I have read has mentioned this point, and I am wondering whether you can elucidate the matter for me. No mention is made in the article of the manner in which the box has to be shaped, so perhaps you could give me some information on this part of the design."

The "tubbiness" referred to by the author of the article in question is a defect that is sometimes encountered with reflex baffles through improper attention, or no attention at all, to the suppression of reflections inside the box, other than those which are intentional at low frequencies, and help to give this type of baffle its superior performance compared with a flat baffle. It can normally be overcome, without specially shaping the box, by the simple expedient of lagging the box with felt, cotton-wool, or other sound-absorbent material. This does not affect the proper operation of the baffle at low frequencies, because no absorbent lining is very efficient at very low audio frequencies, and it becomes progressively more absorbent as the frequency rises. The lagging ensures that the higher frequencies are absorbed instead of suffering multiple reflections within the box, and thereby affecting the speaker cone by being reflected back on to it in random phases. The writer of the article referred to was responsible for the design of a commercial reflex baffle, the details of which we are not at liberty to publish; it is, however, very successful, and embodies the design features mentioned in Mr. Whale's article. However, our own experience with reflex baffles has led us to the conclusion that the "tubbiness" effect is one which is quite rarely encountered, and which will certainly not occur if proper lagging of the box is done.

We do not think that celotex is a good enough sound-absorbent for the purpose, and would recommend an inch-thick layer of cotton-wool or wadding, or else some heavy under-felt such as is used under carpets. It is best not to tack the material on, but to paint the whole of the inside with a suitable glue and then press the material into position, pieces having been cut to shape previously. There is no need to be afraid that the work and expense of making the baffle will not be worth while, as the dimensions are not very critical, and as long as they are somewhere approaching the optimum for the speaker used, the results obtained will undoubtedly be superior to those of any flat baffle, even one of very large proportions.

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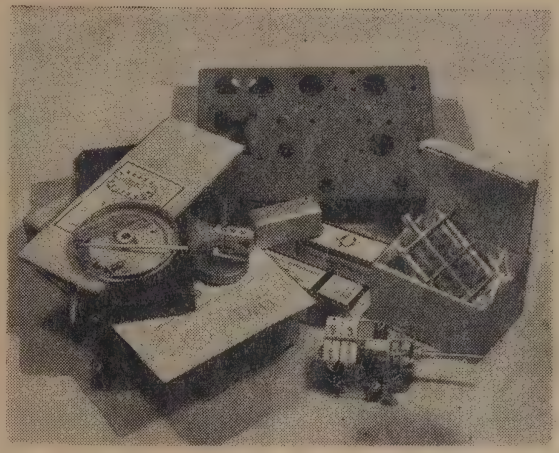

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ANTENNAE AND TRANSMISSION LINES:

Antennae, transmitting and receiving, for Citizens' Radio (U.S.) 460-470 mc. Design requirements of antennae to give adequate gain. Description of colinear vertically polarized array giving 360 degrees coverage for fixed station use, and of six-element array for point-to-point service.

—Electronics (U.S.A.), May, 1948, p. 96.

Antennae resonance. Adjustment of antennae to resonance and matching of transmission lines to antenna by observation of positions of current minima of standing waves along transmission line. Indication of necessary adjustments to secure proper match.—QST (U.S.A.), May, 1948, p. 23.

CIRCUITS AND CIRCUIT ELEMENTS:

Mutual intereference between two broadcast transmitters operating with antennae close together. Two U.S. stations, one 250w. on 1450 kc., the other with the same power on 1490 kc. Result was inter-modulation and spurious radiation. Description of filters incorporated in tuning units to reject interfering frequencies.

—Communications (U.S.A.), March, 1948, p. 18.

Beat frequency tone generator. Principle of resistance-capacitance tuning of oscillators adapted for use with heterodyne tone generator. Details of circuit using two R-C tuned oscillators, one fixed frequency, one of variable frequency to feed appropriate grids of hexode mixer. Frequency of generator is varied by varying control bias of cathode-follower valve, the output impedance of which shunts portion of phase-shifting resistance network in output circuit of variable frequency oscillator.—Electronics (U.S.A.), May, 1948, p. 130.

High stability oscillator. Details of experimental model of modified form of Colpitts oscillator. (See "An Inductance-capacity Oscillator of Unusual Frequency Stability," Proc. I.R.E., U.S.A., March, 1948.) Excellent stability claimed for model using 6J5 valve on 3.5 mc. band (amateur).

—QST (U.S.A.), May, 1948, p. 42.

Production of high-frequency pulses. Correspondent to journal cited below recommends use of Class C amplifier biased well beyond cut-off, fed by sinusoidal voltage, to produce sharp pulses with a recurrence frequency of several megacycles per second. With 6AK5 valve in circuit described, writer has obtained satisfactory pulses as high as 5 mc/s. Reference to H. T. Reich, "Theory and Application of Electron Tubes," McGraw Hill Book Co., 1944, p. 359.

—Wireless Engineer (Eng.), May, 1948, p. 164.

Simplified single-sideband reception. Practical unit for use with communications receiver for s.s.s.c. radio-telephone or c.w. transmission reception. Uses p.p. balanced converters each supplied with demodulating voltages 90 degrees out of phase, feeding 90 degree audio phase-shift network, making it possible to reject signals on one side of beating oscillator and pass those on other. Low-pass filter then employed and as a result effective intermediate frequency bandwidth becomes that of passband of filter.

—Electronics (U.S.A.), May, 1948, p. 82.

Bridge-balanced amplifiers. Description, with circuit details, of D.C. voltage and current amplifiers to give improved sensitivity for V.T.V. meters and photo-electric light meters. Triodes used in balanced-bridge circuits offset the effects of variations in supply voltage and in valve factors.

Electronics (U.S.A.), May, 1948, p. 111.

FREQUENCY MODULATION:

Narrow-band exciter for F.M. (amateur) transmitter uses resistance-variation method of modulation to convert V.F.O. controlled A.M. transmitter to F.M. Plate resistance of last valve of speech amplifier is shunted across part of oscillator anode circuit; as anode resistance varies with audio signal, the oscillator is modulated.

—QST (U.S.A.), May, 1948, p. 40.

INDUSTRIAL APPLICATIONS:

Thickness gauge for moving sheets of glass and other non-magnetic materials from ⅛ in. to 1 in. in thickness. Description of apparatus and circuit details. Material runs between primary and secondary of special transformer energized by a stabilized oscillator. Change in spacing between primary and secondary, due to changes in thickness of material being measured, varies degree of coupling and upsets balance between standard and measuring heads, which are normally balanced in a bridge arrangement. Suitable meter indicates variation in thickness.—Electronics (U.S.A.), May, 1948, p. 90.

MATERIALS AND SUBSIDIARY TECHNIQUES:

Semi-conductors. Developments in the manufacture and use of resistor materials having large negative temperature coefficient of resistance. Composition described, advantages discussed, and uses outlined.

—Philips Tech. Review (Holland), Vol. 9, No. 8, p. 239.

MICROWAVE TECHNIQUES:

Waveguide junctions of form referred to as Magic-T. Mathematical analysis of operation of junction of four rectangular waveguides. Performance discussed. Application possibilities considered, e.g., as impedance bridge, for measurement of high standing-wave ratios, for transmission around difficult corners, as frequency discriminator, and in combination with matched crystal detectors to constitute mixer in microwave receivers.—Wireless Engineer (Eng.), May, 1948, p. 138.

Flat-plate transmission lines used as low-impedance reactances at v.h.f. in lieu of open or coaxial lines. Recommended for use in balanced or unbalanced circuits, particularly from 300-1000 mc. Practical application to a 600 mc. grounded-grid amplifier using planar triode in receiver pre-amplifier. Discussion of uses as matching sections.—Electronics (U.S.A.), May, 1948, p. 93.

MEASUREMENTS AND TEST GEAR:

Description of typical test equipment employed in U.S. broadcast station. Characteristics and operational details of volt-ohm-milliampmeter, audio oscillator, distortion and noise meter, and oscilloscope. Part 1 of article.

—Communications (U.S.A.), March, 1948, p. 22.

Typical U.S. broadcast station test equipment. Part 2 of article. Deals with application of capacitor bridge, V.T.V.M., and signal generator.

—Communications (U.S.A.), April, 1948, p. 20.

Peak indicating modulation monitor. Operates by comparing D.C. and A.C. components which result from diode detection of modulated carrier. Combined D.C. and A.C. output of diode applied to grid of high-mu triode. 100 per cent. modulation results in A.C. voltage driving D.C. to twice normal value and reduces it to zero, alternatively. Triode normally operates at plate current cut-off. A 100 per cent. modulation peak momentarily reduces D.C. voltage to zero, and plate current of triode used to operate an indicator. By varying percentage of D.C. output from diode, any desired percentage of modulation may be measured after unit has been suitably calibrated. Neon bulb used as flasher-type of indicator in combination with gas tube in appropriate circuit to give prolonged flash.

—QST (U.S.A.), May, 1948, p. 70.

TELEVISION:

Description of unit for television studios designed to emphasize the synchronizing portion of composite video signal. Compensates for earlier compression occurring in a relay transmitter and pre-emphasizes sync. in anticipation of later compression in station equipment. Unit also intended to remove hum from the signal, restore low-frequency response, or remove transients. Circuits and application described.

—Communications (U.S.A.), March, 1948, p. 10.

Counter circuits for television. Step-type counter circuits used as frequency dividers in design of television synchronizing generators. Mathematical analysis of basic step-type circuit. Consideration of means of obtaining most stable operation. Circuit of practical frequency divider, deriving parameters from equations given.

—Electronics (U.S.A.), May, 1948, p. 120.

TRANSMISSION AND TRANSMITTERS:

Single side-band suppressed-carrier radio-telephone transmission. Simple explanation of principles, showing that effectiveness of transmitter raised to a degree the equivalent of a power increase of eight times and that concurrently the adoption of s.s.s.c. type of transmission would lead to increase of effective width of amateur phone bands.

—QST (U.S.A.), May, 1948, p. 13.

Crystal-controlled portable transmitter or exciter designed for 220 mc. (amateur) band. Circuit and constructional details of transmitter, which uses crystals in either 8 or 12 mc. ranges. 6J6 combined triode and frequency multiplier, two 6J6 valves as p.p. triplers, and final 6J6 in p.p. neutralized amplifier.

—QST (U.S.A.), May, 1948, p. 20.

40-watt C.W. amateur's transmitter. Design and circuit details for construction of a simple, well-designed transmitter, which may be built either on metal chassis or as wooden rack-and-panel type. Uses 6AG7 crystal oscillator and 807 as amplifier-doubler.—QST (U.S.A.), May, 1948, p. 25.

28 mc. mobile transmitter. Design and construction of transmitter rated at 30 watts input, remotely controlled for use in a car. 807 valve in third and final stage; 7C5p.p. modulators Dynamotor.—QST (U.S.A.), May, 1948, p. 60.

VALVES:

Evacuation of valves and description of eleven standard types of vacuum gauges used to measure degree of vacuum.

—Communications (U.S.A.), April, 1948, p. 22.

Valve noise and transit time. Knowledge assumed of contents of three previous papers on subject of noise (1 Jnl. Ins. Elec. Engnrs., Part 3, 1946, Vol. 93, p. 45, 2 Wireless Engineer, 1946, Vol. 22, p. 333; 3 Wireless Engineer, 1946, Vol. 23, pp. 74-116) and present article applies theory to valve noise when transit time a consideration. Mathematical treatment.

—Wireless Engineer (Eng.), May, 1948, p. 148.

MISCELLANEOUS:

Emergency power supply systems for feeding mains-fed plant in event of breakdown in mains supply. Case for use of single-battery system using battery of lead-cell accumulators in preference to two-battery or dynamo systems with respective attendant disadvantages. Constant preserving charge of 2.1 to 2.2 volts per cell maintained by rectifier of special design, using highly saturated transformer previously described

(Concluded on page 48.)

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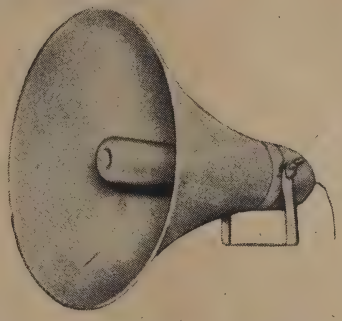

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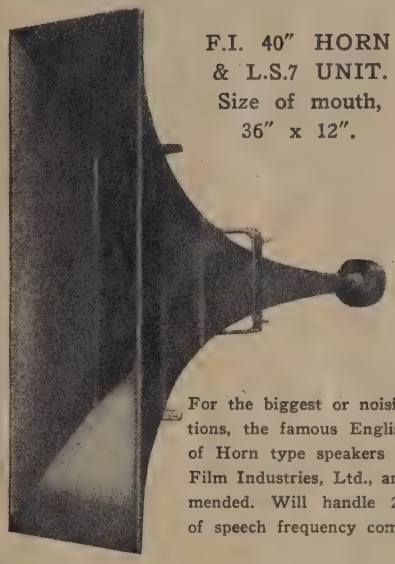

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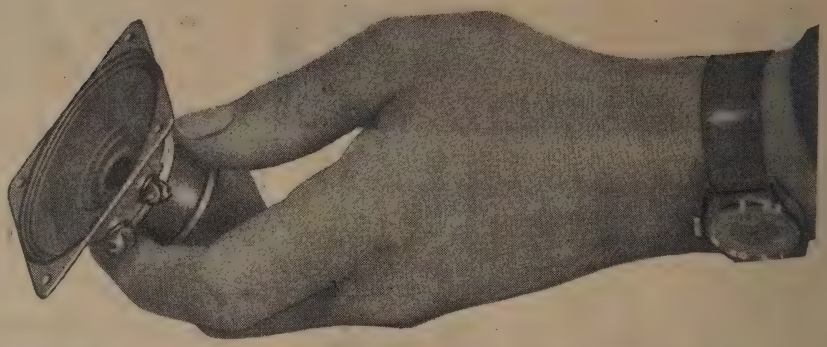

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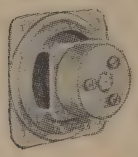

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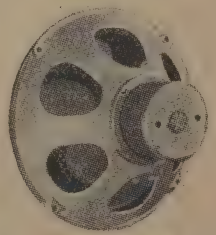

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A Practical Beginners' Course

PART 24

SOME MORE FACTS ABOUT VALVES AS AMPLIFIERS

We have previously discussed the way in which amplifying valves work, but only in a very elementary manner, so that it is about time we had a little more to say on the subject of valves, giving a more accurate idea of just what they do. Since we have now used a valve as an audio amplifier, we will be in a better position to do this than we were a few instalments ago.

In order to know just how a certain type of valve will perform as an amplifier, it is necessary to have some accurate way of describing the electrical characteristics of different valve types. There have been invented three main characteristics which can be expressed as numbers, and a knowledge of which is essential if one is to be able to compare different valve types without actually connecting them up in a circuit and measuring the amount of amplification that can be obtained. If this had to be done, it would be a very difficult matter to make the comparisons between different valves, because, for one thing, the test circuits that were used would have to be standardized. That is to say, the operating conditions under which valves were worked would have to be identical if a true comparison were to be obtained. The method would be very cumbersome, and would not give good results for some types of valve. For example, although such a system would possibly be workable for diodes and triodes, it would certainly not be practicable to use the same methods for comparing pentodes with triodes, or even among themselves, since there can be such wide differences between pentodes of different kinds, that are designed for quite different purposes.

Now the three characteristics or properties that we are about to discuss can be applied equally well to valves with one grid, two grids, or with any number of electrodes. Moreover, these properties can be expressed as numbers, and without reference to any particular circuit, so that they form a kind of shorthand description of the valve itself, quite apart from anything else.

AMPLIFICATION FACTOR

You will remember that some time ago we described how the control grid (or simply the grid, for short) of a triode enables the plate current of the valve to be regulated, or controlled. Now, suppose we have a triode valve, and also some batteries with numerous tappings on them, so that we can place any desired voltage on the plate, or on the grid. At the same time, we have a meter which we can connect in series with the plate battery in order to measure the plate current of the valve. We connect the filament battery, the meter and the plate battery, and also a grid-bias battery, in the way described in the last instalment for our audio amplifier. We do not make any arrangements for feeding an alternating signal voltage on to the grid, or for taking such a signal out of the plate circuit, for all we are interested in at the moment are the D.C. voltages and currents in the circuit. We will suppose, further, that the valve we are examining is a type 30, and that we have unlimited batteries for getting as high a plate voltage as we please.

First of all, we connect a bias battery of —8v. between filament and grid, with, of course, the positive terminal to filament and the negative terminal to the grid. Now, we put a positive plate voltage of 120 on to the valve, and on reading the plate current meter, we find that there are 2.5 ma. flowing. Now, we change this plate voltage to, say, 160v.; the plate current, we notice, increases to a value of 6.5 ma. Next, we reduce the plate voltage to 80v., and we find that the current is now only about one-tenth of a milliamp.

What, if anything, have we discovered by this simple experiment? First of all, let us see what we have done. We have kept a constant negative grid voltage of —8v., and we have varied the plate voltage, in steps, from 80 to 160. What we have discovered is this, that, when the plate voltage is varied in this way, the plate current varies also, from 0.1 ma., at 80v., to 6.5 ma. at 160v. **In short, if the grid voltage is kept fixed and the plate voltage is varied, the plate current is higher the higher the plate voltage.**

Now, the question arises: "What will happen if we fix the plate voltage and vary the grid voltage?" This is easily settled by performing another simple experiment. We fix the plate voltage at, say, 160v., and, as before, we find that, with a grid voltage of —8, the plate current is 6.5 ma. This time we alter the grid voltage to —4v., and find that the current has increased to 11 ma. Next, the grid voltage is altered to —12v., and it is found that the current has dropped to 2.5 ma. The conclusion to be drawn from this second experiment is that, **if the plate voltage is kept constant, and the grid voltage is varied, the plate current is higher the smaller the negative grid voltage.** So far, we have not found out anything we did not know already, but if we examine the figures that have been obtained, it should be possible to gain a little further information.

In the first experiment, when the plate voltage was changed, it took a variation of 80v. in the plate voltage to change the plate current by approximately 6.4 ma. In the second experiment, when the plate voltage remained constant and the grid voltage was varied, the latter, when changed by only 8v., caused the plate current to change by 8.5 ma. This is a much greater control than is exercised by the plate voltage, and forms a practical demonstration of a fact that has been stated before. By doing a little arithmetic, using the above figures, it can be seen that a grid-voltage change of only 6v. is able to cause as much plate-current change (6.4 ma.) as an 80v. change in plate voltage. **Thus, the grid is 80/6, or 13.3 times as effective as the plate in controlling the plate current.**

This figure of 13.3 is called the **Amplification Factor** of the valve. It is a number, which will be different for each valve type, and which is a great help in telling us what kind of a valve we are dealing with. For example, it tells us that under no circumstances can this valve amplify a signal by more than 13.3 times. In addition, as we will find later, it indicates directly whether the valve concerned is suitable for some kinds of work.

To sum up, the amplification factor of a valve may be defined as follows: **"The amplification factor of a valve is the ratio between the change in plate voltage and the change in grid voltage neces-**

sary to produce the same small change in plate current."

MUTUAL CONDUCTANCE

The next most important factor which gives information about a valve is called the **Mutual Conductance.** This factor is more easily explained than the amplification factor, and we may well commence its discussion with a definition of it. **"The mutual conductance of a valve is the number of milliamps by which the plate current changes when the grid voltage is changed by one volt."**

This also can be illustrated by the few measurements that we took in order to illustrate the amplification factor. Referring back to an earlier paragraph, we find that changing the grid voltage by 8 volts caused the plate current to change by 8.5 ma. Thus, if the grid voltage had been changed by only one volt, the change in plate current would have been 8.5/8, or 1.06 ma. The mutual conductance can therefore be said to have a value of 1.06 milliamps per volt, or, as it is more usually written, 1.06 ma/v.

The amplification factor and mutual conductance are known as **valve constants**, and together with a third known as the **plate resistance** they form an almost complete picture of the valve type. In a later instalment we will describe the meaning of the term plate resistance, and will have some more to say about valves, particularly with reference to the curves that are published in the manufacturers' data books.

(To be continued.)

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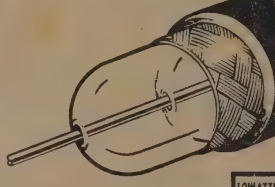

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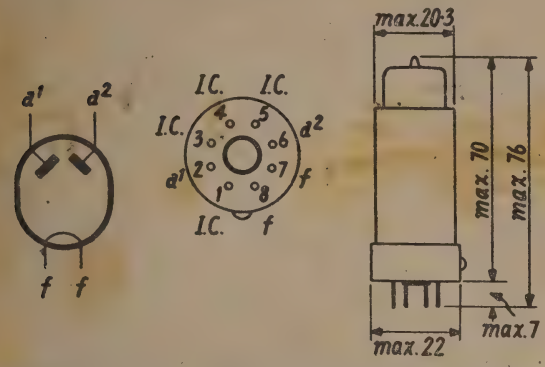
TUBE DATA

THE EF41 RIMLOCK R.F. PENTODE



Electrode arrangement, under-socket connections and dimensions of the EF41.

The EF41 is a variable-mu R.F. pentode designed for application to tuned radio frequency or intermediate frequency amplifiers in receivers. It is also useful as a resistance coupled audio frequency amplifier, with or without automatic gain control. It has a high mutual conductance for a tube of its class, this being 2.2 ma./v. for the normal operating conditions of 250v. on the plate, and a screen supply of 250v., applied through a dropping resistor of 90 to 100k. It will be noted that the mutual conductance is considerably higher than that of the EAF41. Thus, the latter should be used only when the diode is needed, because the stage gain possible with the EF41 is considerably greater than that possible with the EAF41, other things being equal. Characteristics and curves for the EF41 are given below.

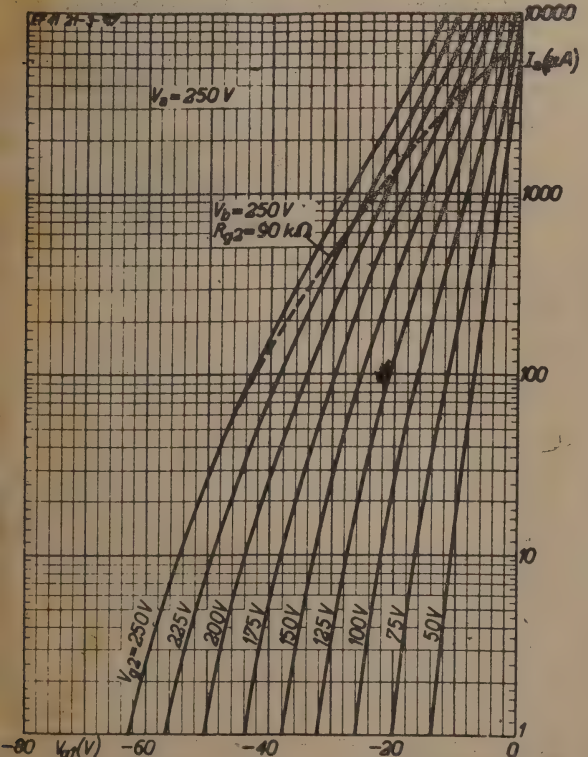
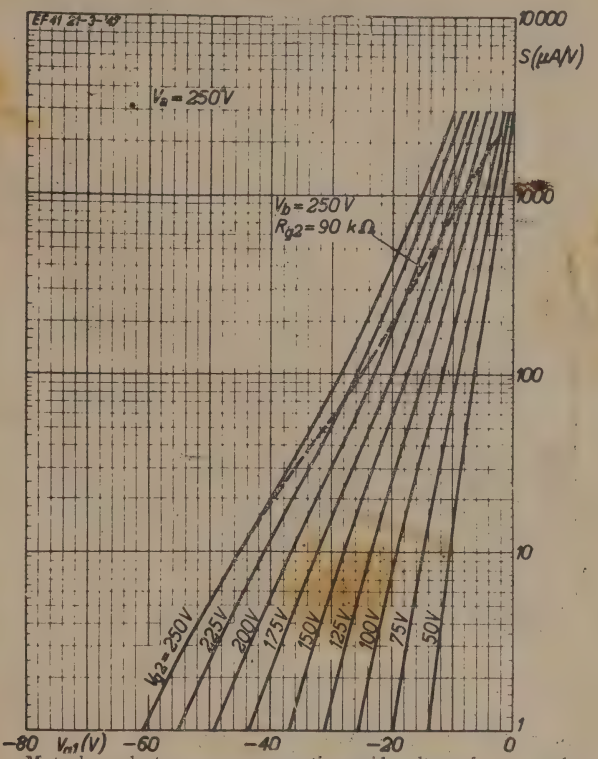
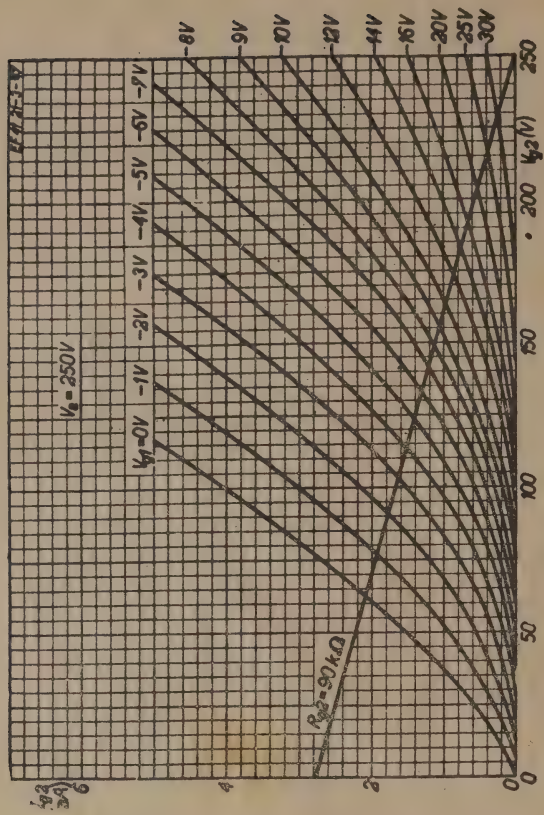


Plate current versus negative grid voltage for a number of screen voltages.



Mutual conductance versus negative grid voltage for a number of screen voltages.

Heater:		
Heater Voltage	6.3v. A.C. or D.C.	
Heater Current	0.2 amp.	
Capacities:		
Control-grid to Plate	< 0.002 μμf.	
Output Capacity	8.0 μμf.	
Input Capacity	4.7 μμf.	
Control-grid to Heater	< 0.05 μμf.	
Typical Operating Conditions:		
Plate Voltage	250v.	
Screen Dropping Resistor	90k. ohms	
Cathode Resistor	325 ohms	
Grid Bias	— 2.5v.	— 39v.
Plate Current	6.0 ma.	—
Screen Current	1.7 ma.	—
Mutual Conductance	2.2 ma/v.	22 a/v.
Plate Resistance	1 meg.	> 10 meg.
Amplification Factor (Grid to Screen)	18	—
Equivalent Noise Resistance	7.4k. ohms	—
Limiting Values:		
Plate Voltage ($I_a = 0$)	550v. max.	
Plate Voltage (Plate Current Flowing)	300v. max.	
Plate Dissipation	2 watts max.	



Triode characteristics, i.e., screen current versus screen voltage for various negative grid voltages.

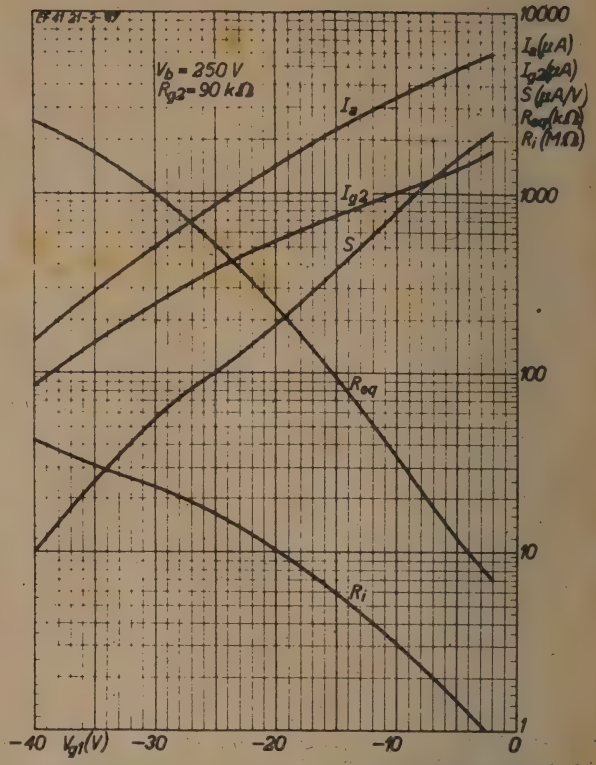


Plate current, screen current, mutual conductance, plate resistance, and equivalent noise resistance versus negative grid voltage.

Screen Voltage ($I_a = 0$)	.....	550v. max.
Screen Voltage ($I_a = < 3$ ma.)		300v. max.
Screen Voltage ($I_a = 6$ ma.)	.....	125v. max.
Screen Dissipation	....	0.3 watts max.
Cathode Current	....	10 ma. max.
Grid-Cathode Resistance	.....	3 megs. max.
Heater-Cathode Resistance	.....	20k.ω max.
Heater-Cathode Voltage	.....	50v. max.

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AUCKLAND DUNEDIN

807's AS AUDIO AMPLIFIERS

(Continued from page 19.)

120k. ohms. It is realized that the resistors used will have tolerances of between 10 and 20 per cent., and that on this account specifying these values will not necessarily mean that perfect balance will be got if any two resistors are chosen at random, but, if desired, the extra piece of load resistance can be obtained by using identical 100k. resistors for both halves of the valve and by connecting a variable resistor of, say, 50k. ohms in series with the load resistor of the second half of V_2. Exact balance can then be obtained by adjusing this variable resistor until a 'scope shows that the outputs from the two halves are equal.

THE OUTPUT STAGES

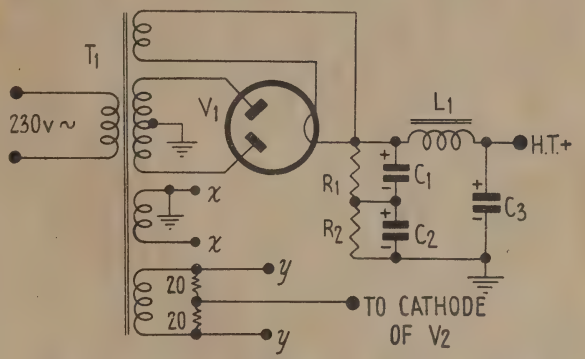
The output stages in the two amplifiers are, of course, different. In Fig. 1, the triode amplifier, it will be noted than the screen grids are connected to the plates of the valves, and NOT to the control grids. This makes it necessary to take quite a long lead through the chassis from the socket to the top-cap plate connection; it can also be seen that the two elements are not directly inter-connected, but that a small resistor is placed between each screen and plate. This is by way of a screen stopper, preventing parasitic oscillations. Also included are grid stoppers, for the same reason. On no account should either be omitted. If the feedback links are disregarded, the output stage can be said to be very ordinary in its circuit. Cathode bias is used, and the bias resistor is left unbypassed. There is no necessity for such bypassing, as the audio currents from the individual valves are out of phase, and to the extent that the output stage is properly balanced, there is no audio frequency voltage to be found across the cathode resistor.

On Fig. 1, there have been shown alternative connections for the negative feedback. One way of making the connection is to earth one side of the output transformer secondary and take a lead from the other side, through the feedback resistor, R, to the cathode of V_1. The degree of feedback is governed by the relative sizes of the feedback resistor and the V_1 cathode resistor. Since the latter is fixed, this leaves the former as the sole variable. The other method of connection is to use a large coupling condenser (in this case 4 mfd.) from the plate of the appropriate valve to the feedback resistor. These alternatives have been suggested in order to give the constructor some choice in selecting an output transformer. If the latter is included in the feedback chain, the phase-shift in it is added to that of the rest of the amplifier; thus, when a high-fidelity output transformer is used, it is possible to connect the feedback from its secondary. If a cheaper one is used, it may not be possible to employ enough feedback from the secondary, on account of either motor-boating or high-frequency oscillation. In this case more satisfactory results will be obtained by using the alternative connection.

On Fig. 2, no alternative method has been indicated, as with the tetrode circuit, the best arrangement was found to be the one shown. This is not at all serious, as the distortion arising in a really high-quality transformer is very slight, so that if feedback is not put round it, it does not matter very much.

VALUES OF COUPLING CONDENSERS AND GRID RESISTORS

In the ordinary run of audio amplifiers, when no feedback is used, the exact values of the grid resistors in resistance-coupled stages, and of the coupling condensers, are not usually regarded as very important. The main thing is to have the grid resistors small enough for good high-frequency response, and the coupling condensers large enough, in relation to them, for good low-frequency response. (Of course,



Power supply suitable for either of the amplifiers mentioned in the text.

T_1, 350-0-350v. 150 ma. 6.3v., 6.3v., 5v.
L_1, 30H., less than 300ω resistance. V_1, 83v. or 83.
R_1, R_2, 1 meg. C_1, C_2, C_3, 16 μf. 450v.

Note: For triode amplifier T_1 need be rated only at 100 ma.

there are other things that enter into the choice of values, but these are the most important items.) However, when feedback is placed round a number of stages in an amplifier, as here, the frequency response of each stage, and therefore the value of these components, has to be carefully matched. Thus, if the low-frequency response is carried too far down, the result may be motor-boating. Similarly, high-frequency oscillation may occur if the high-frequency response is not good enough, and equally, under some circumstances, if it is too good.

A WARNING

For these reasons, it is necessary to warn intending builders that **the values recommended for the two circuits given in this article should be adhered to quite strictly.** For example, if any attempt is made to increase the size of the coupling condensers, trouble will almost certainly be experienced from motor-boating. This is due to the increase in response of the amplifier at frequencies so far below the audio range as to be quite useless—namely, below ten cycles per second. Thus there need be no fear that the response of the amplifiers is not already good enough at the extremes of the audio range. In the case of the low end, the measured response is flat down to 20 c/sec., and exhibits a very slightly rising characteristic down to 15 c/sec.

FIXING THE VALUES IN THE FEEDBACK CIRCUIT

The values we have given for the feedback resistor are minimum values. That is to say, the smaller this

resistor, the greater the feedback, with the result that the resistor in question cannot be reduced beyond a certain point. It is possible that with different mechanical arrangements from the one used by us in our experimental work on the amplifiers, the amount of feedback that can be successfully used will differ from our figure. This is not very likely, in our opinion, but it is as well to be prepared for all possibilities. The best way to fix the value of the feedback resistor is to put a resistive load on the secondary of the output transformer and to examine the output waveform on an oscilloscope. The feedback is then increased by decreasing the value of the feedback resistor until either motor-boating or H.F. oscillation is encountered. Usually, one of these will occur first; which one, it is not very important, as the onset of either represents the limit to which feedback can be taken. If motor-boating does not occur, it is necessary to see that no high-frequency oscillation takes place until **after** full audio output has been obtained. This is easily seen when the output waveform is examined, as the onset of distortion in the audio waveform is recognized separately from the high-frequency oscillation, which appears as "fuzz" on the trace, usually at one spot on the output wave. If this occurs AFTER full audio output has been obtained, it does not matter, since the amplifier will presumably not be run at a higher level than this. The value of the feedback resistor is adjusted until the oscillation does not take place before the amplifier is overloaded by the signal proper. Motor-boating shows up on the 'scope as a slow periodic shift in the position of the pattern. The shift is, of course, in the Y direction, since the motor-boating is nothing more than a very low-frequency oscillation. The values of coupling condensers and grid resistors in the two circuits given here have been chosen to allow as much feedback as possible to be applied, so that there is little point in attempting to better them.

CONCLUSION

In this article we have placed rather more emphasis than usual on the theoretical aspects of the circuits, and have given no specific instructions as to the physical lay-out to be used. This does not mean that the circuits have been made to work very well indeed, or that they are in the nature of experimental circuits which may need some trouble on the part of the constructor before they can be regarded as satisfactory. These two basic amplifiers have been fully tested in our laboratory, with very fine results, and we have no hesitation in recommending them to anyone who is looking for a circuit which will make use of 807's in the best pos-

(Concluded on page 48.)

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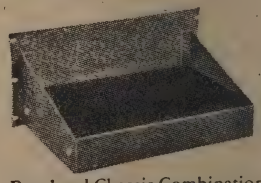
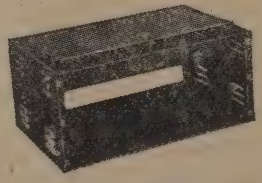


Panel and Chassis Combinations



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OUR GOSSIP COLUMN

Two hundred guests enjoyed a reunion smoko of ex-employees and business friends of Radio (1936), Ltd., given by the Chairman and the Board of Directors of that company.

In extending a welcome on behalf of his committee, Mr. Bill Murphy (Chairman) expressed his pleasure in the opportunity thus afforded to welcome representatives of younger firms engaged in radio, and hoped that this "get together" would be a forerunner of many such gatherings. The Committee considered that such would do much towards better relationships between those engaged in the trade in Auckland.

The guests enjoyed a short talk given by Mr. Truscott, who expressed his pleasure at seeing so many of his old friends, and congratulated those present on the part they had played in building up the industry in Auckland.

With concentration inherent in those associated with radio, the guests applied themselves with celerity and expedition to the consumption of liquid refreshment, whilst merriment and noise level increased in proportion to the rate of flow of the very popular ale.

Highlight of the latter part of the evening was the glee-singing of the guests, which proved entertaining, even if the harmony was a little discordant and throaty at times.

Among those present, readers will recognize the names of many well-known members of the radio industry, including Messrs. W. J. Truscott (Chairman of Board of Directors of Radio (1936), Ltd.), G. A. Wooller (of Messrs. G. A. Wooller and Co., Ltd.), Staff, Borthwich, and Hardstaff (of Messrs. H. W. Clarke, Ltd.), Forte and Black (of Westonhouse Radio, Ltd.), R. Harrington (of Swan Electric Co., Ltd.), Ingram, McCrae, and Carruthers (of Messrs. J. J. Niven and Co., Ltd.), F. Noad (of Auckland Photo Engravers), H. Buscomb and Thompson (of Custom Moulders), and Joe Pelham (of J. C. H. Pelham and Sons, Ltd.).

* * *

Jim Eckford, of S.O.S. Radio Ltd., paid a visit to the Capital recently on one of his sales drives. Overflowing with his usual enthusiasm, Jim sure gets his full share of what's going!

* * *

We also received a bright cheerio recently from another popular Aucklander—Dave Craig—who was looking as fit as ever.

* * *

Friends of Mr. Walter Green of Green and Cooper Ltd. will regret to hear that he has been having a sojourn in hospital. Here's wishing you a speedy return to health—and Lower Taranaki Street—Wally!

* * *

DUNEDIN TO THE FORE

Readers will be interested to learn that the world-wide competition originated by Messrs. Stratton & Co., Ltd., England, whose New Zealand agents are Messrs. Arnold & Wright Ltd., has been won by Mr. Collett of 29A Duncan Street, Dunedin. Details of this competition were published in the March, 1948, issue of "Radio and Electronics," and we feel that this is a great honour to have been carried off by New Zealand. Congratulations, Mr. Collett. For the information of readers, the prize is an Eddystone 640 receiver.

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The present-day difficulty in buying homes is proving no obstacle to G. MacLennan, Production Manager, and M. O'Sullivan, Sales Executive of National Carbon Pty. Ltd. Both have recently purchased adjoining sections, and are now busily engaged each week-end in erecting future homes. The spirit of co-operation is abroad, and a Busy Bee of "Evereadyites" is lending a helping hand. We understand that payment is made in liquid refreshment. Top marks to George MacLennan and Maurie O'Sullivan.

* * *

George Pollock, progressive radio dealer of Auckland, visited Wellington recently en route to Dunedin, where, we understand, a change from radio to politics was the order of the day. How do you find the spare time, George?

* * *

Mr. R. D. Greenwood, Managing Director of National Carbon Pty. Ltd., is now in New York. During his absence C. H. Hart is keeping an eye on things, including the "New Look" refills. Incidentally, Frank Marker has now taken over in the North Island territory as "Eveready" representative, and is looking forward to contacting all dealers during the next few months.

Talking of the "New Look," dealers seem to be taking advantage of the new "Eveready" labels and cartons in which "Eveready" products now appear, and a number of very attractive window displays have been noticed around Wellington.

* * *

Les Chaston, Proprietor of Radio and Electrical Exchange, Wellington, has now extended his activities to the mass production of personal portable radios, and may be seen at any time dashing round Wellington with a neat and efficient small type personal set. If Les receives any more orders, twenty-four hours a day will be insufficient, but he says, "It's really worthwhile."

OBITUARY

We record with deepest regret the sudden passing at Dunedin on 9th July of Mr. Charles Eric Begg, Chairman of Directors and General Manager of Messrs. Charles Begg and Co., Ltd., and of Dominion Radio and Electrical Co., Ltd.

Eric Begg, as he was popularly known, will ever be remembered for his unremitting energy devoted not only to the successful operation of his firm's interest, but to many and varied voluntary services to musical circles, Health Camps, Christian and civic activities, etc., and his early passing at the age of only 50 years will be mourned by those in all walks of life.

Members of the radio trade will recall the many years of active service rendered by Mr. Begg towards the advancement of the industry where he will be specially missed for his wise counsel in future developments.

We extend our deepest sympathy to the members of his family and the staff of the Chas. Begg organizations.

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THE EDITOR'S OPINION

MESSRS. SWAN ELECTRIC CO. LTD.'S MIDGET I.F. COUPLING UNIT

To meet the demand for a very small transformer for the intermediate frequency amplifiers of midget receivers, portable or otherwise, Messrs. Swan Electric Co., Ltd., have produced the coupling unit illustrated on this page. Its extremely small size is seen by comparison with that of an ordinary match-box, and its design and performance are the subject of this month's Editor's Opinion.

NOT A TRANSFORMER

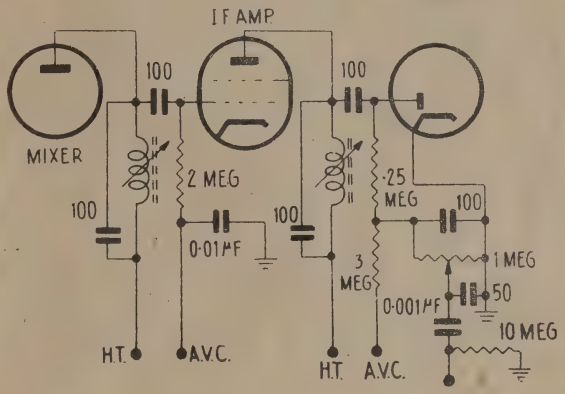
At the outset, it should be made clear that in order to achieve this minuteness, without sacrificing anything in the way of performance, the designer has made a somewhat revolutionary departure from standard practice, in making the unit in the form of

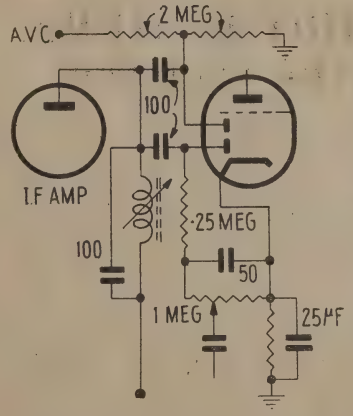
This photograph shows the appearance of the units, and their size compared with a matchbox.

a single-tuned winding, rather than the normal double-tuned transformer. Set designers have become so used to seeing the latter in superheterodyne circuits that the particular merits of using single-tuned circuits, with resistance-capacity coupling in the grid of the I.F. amplifier, have been largely forgotten. In presenting to the industry a unit such as this, which necessitates a change from what has become a standardized circuitry, it therefore seems desirable to enlarge to some extent upon the single-tuned system of inter-stage coupling, and to expound its merits and demerits, if any, when compared with the transformer-coupled I.F. amplifier.

SENSITIVITY AND SELECTIVITY

Of most interest to intending users of these units will undoubtedly be the question of how the single-tuned system will affect the sensitivity and selectivity of a receiver, if at all, as compared with the conventional system. It is well enough known that the stage gain of an I.F. amplifier depends upon the Q of the tuned circuits that make up the I.F. transformers. It is probably not so often realized, however, that in a double-tuned transformer, the presence of the tuned secondary winding, critically coupled to the primary, effectively halves the Q of the primary. In similar fashion, the presence of the primary halves the Q of the secondary. This means that, if the secondary were removed and the transformer reduced to a single-tuned circuit in series with the plate of the mixer (or I.F. amplifier), the voltage gain of the tube itself would be twice the figure obtained when the transformer is used. In the latter, the signal voltage coupled into the secondary winding is so small that, even after amplification by the Q of the secondary, the signal voltage appearing at the secondary is less than the signal voltage at the plate of the preceding valve. In other words, there is a net loss in signal voltage from the primary to the secondary of an I.F. transformer. Now, if a single-tuned circuit is used instead, not only is this loss eliminated, but also the actual Q of the plate winding under working conditions, and therefore its dynamic impedance, is able to be much higher. Since the gain of the valve is directly proportional to the dynamic impedance of the tuned plate winding, and since the whole of the signal appearing at the plate of the valve is now applied to the grid of the succeeding one, the result is a considerably increased stage gain, compared with that obtainable from a transformer-coupled stage in which the individual windings have the same characteristics as the single one that has been discussed.





Above: Suggested circuit and valves for using the couplers in a battery portable receiver. Both I.F. stage and second detector are shown.

At Left: Suggested circuit for detector and A.V.C. rectifier when an A.C. type of double-diode-triode or pentode is used.

As for the selectivity, it might appear that, since the I.F. amplifier with single-tuned circuits has only two of them as against the four tuned circuits of a similar transformer-coupled stage, the selectivity of the single-tuned arrangement would be drastically worse. In practice it is found to be only very slightly worse than that of the double-tuned system, and a little consideration will show why.

The Q of the single winding is twice that of the same winding if used as the primary of a transformer, other things being equal, so that the same effect which causes the stage gain to be higher

also causes the selectivity of the I.F. channel, as far as the grid of the I.F. stage, to be approximately the same as if the transformer had been used. At the plate of the I.F. amplifier valve, however, there is a slight loss in selectivity, because the loading effect of the diode detector's load resistor is no longer isolated from the plate winding, and is, in fact, shunted across it. This winding therefore has somewhat less selectivity than the therefore has somewhat less selectivity than has the second I.F. transformer in the conventional system. On balance, then, the single-tuned couplings can be expected to have slightly less selectivity than the transformer-coupled one. Since the selectivity of the average broadcast receiver is more than adequate for station separation with channels spaced 10 kc/sec. apart, this slight loss will make a negligible effect on the performance of the receiver. This applies even more forcibly to portable receivers with their small aerials.

DESCRIPTION OF THE UNITS

The external form of the units can be seen from the photograph. The can is of spun aluminium and the plug-in base is in the same form as a midget speaker plug, except for the threaded shaft which comes through the base and which operates the tuning slug. Internally, the coil is wound with litz on a $\frac{3}{8}$ in. former, and is totally enclosed in a small iron-dust pot. The coil assembly is enclosed in a bakelized paper tube, which has a disc at the upper end whose purpose is to prevent the slug from moving farther than the position from maximum inductance. The internal assembly is so constructed that when the can is assembled and crimped on to the base, the coil and its mounting is kept under firm but safe pressure. By this means it is made impossible for the coil, its pot, or the slug to work loose or to shift in any way.

TUNING AND FREQUENCY COVERAGE

In making the unit so small, it has not been possible to place the fixed tuning condenser inside the case. In order to overcome this difficulty, the chassis-mounting base supplied with each unit is sold with two 100 $\mu\mu$f. ceramic or silver-mica condensers, one of which is to be wired as the tuning condenser, and the other as the coupling condenser. Thus, the unit as purchased is a complete coupling unit, and not just the tuned circuit.

The frequency range covered by the unit is from 452 to 502 kc/sec. This was measured on a unit picked at random from a number that had just been run off. As an indication of their performance, the same unit was measured for Q, and was found to have a Q of 125 at the nominal operating frequency of 465 kc/sec. This is actually better than many windings to be found in full-sized I.F. transformers.

CONCLUSION

It can be said, in summing up our examination of these units, that for compactness, combined with high performance, they can be expected to give results not only comparing favourably, but actually exceeding those of many double-tuned transformers, midget or otherwise, and that to have produced them in a size which occupies one one-fifth the volume of a normal midget I.F. transformer is somewhat of a feat on the part of the designer. The circuits given on this page show how the units may be applied, and even a cursory examination will show that there are no complications or difficulties to be expected in putting them to use. These components should form fitting companions to the miniature tubes that have now become almost standard for portable receivers.

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FREQUENCY RESPONSE OF R.-C. AMPLIFIERS

(Continued from page 8.)

since it is at low frequencies that its reactance becomes high. The coupling condenser and the following grid leak therefore act as a voltage divider for the low frequencies, so that only a portion of the voltage appearing at the plate of the first valve reaches the grid of V_2. Fig. 2 (b) shows the effect of keeping the value of R_{g2} constant and varying the value of C_c. The way in which the low-frequency response varies is very similar to the behaviour exhibited by the high-frequency curves of Fig. 2 (a). The response at middle and high frequencies is unaffected by the value of C_c, and the shape of the fall in response is the same for all values also. What does alter as C_c is changed is the point at which the falling-off commences. The dotted curves to the left and right of the full one in Fig. 2 (b) show the effect of larger and smaller values of C_c respectively.

(To be continued.)

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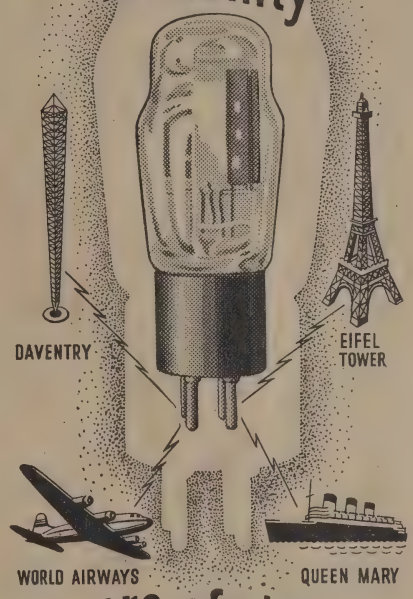

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TRADE WINDS

THE MANUFACTURE OF PAPER CAPACITORS

By D. Selfe, Works Manager of the Wellington (N.Z.) Factory of Ducon

The impregnated Paper Dielectric Capacitor has a large and varied application consistent with constant developments in the radio and electrical fields. Probably the best-known "paper" capacitor is that commonly referred to as the "tubular" or "pigtail" capacitor, which we designate as the PC type. This type is, through its physical and electrical size and price, particularly suited to communication equipment.

The Ducon tubular capacitor is manufactured in a capacitance/voltage range which has been determined by communication equipment requirements. The application of this capacitor calls for further requirements—that it be non-inductive, that insulation resistance be high, and that varying climatic conditions do not materially affect its characteristics, to mention a few. Although a mass-produced article, the modern capacitor is produced with consideration of the relationship of the variable characteristics and an analysed quality control is maintained throughout production with respect to these characteristics.

The capacitor is wound using aluminium or tinfoil and capacitor paper, both materials conforming to rigid purity specifications. The number of papers used as a dielectric between foils is dependent on the required working voltage of the finished capacitor. The rolls of paper and foil are of the same width and during the initial adjustment of the winding machine they are set up so that, with all papers tracking, an overlapping of the two foils results in a wound unit which has a foil edge protruding at either end.

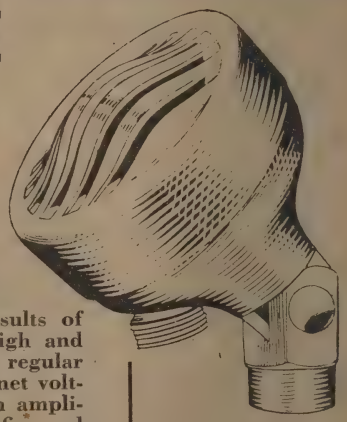
Now, if the wound capacitor unit is of such a size that tinfoil was used in its winding, the attaching of a lead by soldering (the usual puddle-pot dip method being used) is a simple matter. However, if the wound unit incorporates aluminium foil, the attaching of the lead necessitates an operation known as bonding. With a layer of special aluminium solder the protruding foil is bonded—that is, a layer of aluminium solder is introduced to the foil so that the tinned copper wire lead as is required for general application or the flexible tinned braid lead, which is particularly suited for use in R.F. transmission, may be attached.

By the attaching of the lead as with the small physically sized unit (using tinfoil) or through the bonding of the aluminium unit, the capacitor unit now has the individual layers of foil joined together and is therefore non-inductive.

The next operation, that of impregnation, is one requiring rigid control, as it is here that most of the electrical properties of the finished capacitor are determined. During the impregnation cycle, any moisture that may have been absorbed by the component materials either before or during the manufacturing processes is completely driven off by a

UNUSUAL RESPONSE

in sales too . . .



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tank and, by further evacuation and atmospheric treatment, the capacitor units are thoroughly impregnated. Immediately following the conclusion of the impregnating cycle, samples of the capacitors are subjected to quality tests to determine the resultant quality of the impregnating cycle.

The samples are tested for insulation resistance, capacity, and also subjected to a D.C. voltage flash test equivalent to several times their rated D.C. working voltage. The samples must all pass these tests before the recently impregnated capacitors are allowed to continue through the process of manufacture. If successful results of these qualitative tests are obtained, the impregnated capacitors are removed from the impregnating tank and stored in a desiccator until they have cooled to normal room temperature.

While the process of impregnation has been under way, the cardboard tubes within which the capacitor will later be sealed, have been prepared. This preparation consists of first drying out or removing the moisture present through absorption from the atmosphere by drying the tubes in an oven. When devoid of moisture, the tubes are impregnated with a suitable impregnant to assist in the final sealing of the container.

The capacitors—and here we note that no longer are they referred to as capacitor units, as before impregnation they did not possess the electrical characteristics required of the finished capacitor—are now individually subjected to a capacitance test. Any capacitor not having a capacitance within a tolerance of ± 20 per cent. of rated capacitance is rejected. During the capacity test and following manufacturing processes, a constant check is kept on the insulation resistance of the capacitors.

Tubing, or the insertion of the capacitor in the impregnated tube, is the next process step, and this is immediately followed by the sealing of the tube. This is accomplished by filling the ends of the tube with a potting compound, and when this compound is hard, the capacitor is dipped in wax so as to provide a final moisture seal.

Each capacitor is then subjected to a D.C. voltage flash test of several times the rated D.C. working voltage, and, upon satisfactorily passing this test, a visual inspection completes the production of the P.C. type (tubular) capacitor.

Several samples are then taken away from the batch for life tests and stored in an open rack to allow constant air circulation. At regular intervals these capacitors are subjected to insulation resistance tests, and so a constant quality check is kept on production and component materials.

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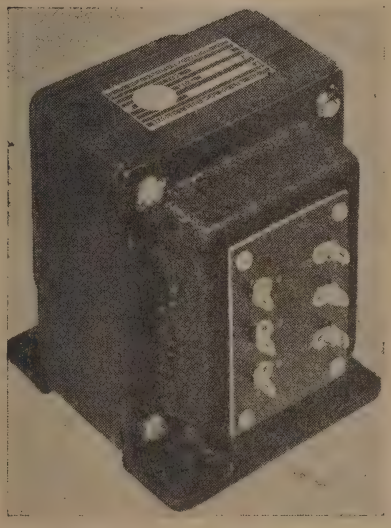

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No. 10a: A PRESELECTOR FOR TEN AND SIX METRES
PART 2
MECHANICAL CONSTRUCTION

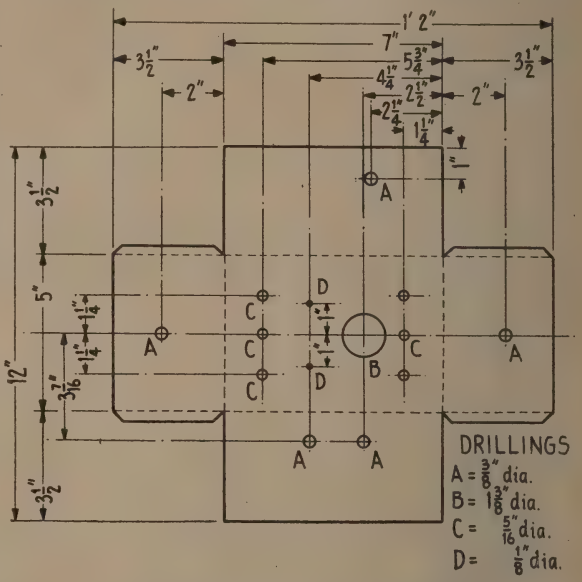
In response to numerous requests, we have given a working drawing for the chassis of the preselector, and have also made the under-chassis photograph larger than usual so that the parts can easily be identified. It is built on a chassis 7 in. x 5 in. x 4 in., and the requisite holes are shown in the drawing. All components except the valve and the two coils are to be found under the chassis, so that external appearance is very clean, and coil changing is facili tated. The coils are mounted by means of Belling-Lee type "OZ" plugs and sockets. These are of about the same dimensions as the old-fashioned so-called "banana" plugs, but are very well made and have a large silver-plated contact area which makes them ideal for handling R.F. without noticeable losses. The sockets are self-insulating and mount by means of a nut. Each coil requires three sockets, and these can be seen in the photograph at either end of the chassis. In the photograph, the input end of the circuit appears at the bottom. The placement of the Polar two-gang condenser, which is used as a split-stator, can be seen to give very short leads both to the coil sockets and to the grid of the EF50. The minute 5 $\mu\mu$f. input and output condensers, which are Eerie Ceramicons, can be seen going to the Amphenol connector at the top, for the output, and to the large terminal at the botom for the aerial. The grouping of the earth connections can be seen, too, and should be copied by the constructor. Solder lugs are mounted under both holding screws of the valve socket, and the left-hand one in the photograph is used for all the R.F. earths, either directly as in the cases of the plate bypass and cathode bypass condensers, or through the earthed group of socket pins, which are connected to this point by a single short piece of wire. It is most important to connect together at the socket the two pins (Nos. 5 and 8) which go to the internal shielding, and the centre shield on the socket and earth, all of them by means of the above-mentioned single wire. Also grouped with these is the earthed side of the heater, which can be made pin 9, for convenience, being next to pin 8, already mentioned. The way in which the socket is turned when it is screwed down is important, too, and the correct orientation is with pin No. 9 to the right, looking at the illustration. This places the grid pin, No. 7, very close to the appropriate stator lead on the variable condenser. Note also the placement of the screen bypass condenser, which is the one INSIDE the ring of pins, and is connected directly between the screen pin, No. 2, and pin No. 4. The condenser is so placed because it thereby adds to the shielding between the plate and grid pins of the socket.

ABOVE-CHASSIS SHIELD

It will have been noticed that the coils, though well spaced, are mounted with their axes parallel. This introduces the possibility of inductive coupling between them, and in practice this does occur unless a baffle-shield is placed on top of the chassis. A suitable place for this is between the grid coil and the valve. It is most convenient, too, for mounting purposes, because the two holes used for mounting the variable condenser are then used also for the partition. This is 3 in. high by 4½ in. long, and has a ¼ in. flange along the lower edge, in which are mounting holes corresponding in position to those on the chassis for the gang condenser.

DIALS

Since it enabled all the wiring to be kept so short, the arrangement shown for the relative positions of the tuning and gain control shafts was decided upon, even though their proximity prevents a large-sized tuning dial from being used. This is quite unnecessary in any case, as, although the tuning is very sharp, taking the frequency and the smallness of the tuning condenser into account, it is not at all critical, and there is no need at all for anything but a plain knob. There is room, however, for a small dial plate of the kind used for indicators on gain controls, and this, in conjunction with a small pointer-type knob, is all that is needed.



Working drawing of the preselector chassis.

COIL SPECIFICATIONS AND CONSTRUCTION

Winding data for ten and six-meter coils are as follows:—

Ten Metres:

L_1, 14 turns of 20-gauge enamelled wire, outside diameter ¾ in., spaced to occupy 1¼ in. of winding space. Tapped at seven turns.

L_2, 12 turns of the same wire, same O.D., and same length, tapped at three turns from H.T. end.

Six Metres:

L_1, 10 turns of same wire, occupying 1 in. winding space tapped at 5 turns.

L_2, 8 turns of same wire, same O.D., same length as L_1, tapped at 2 turns from H.T. end.

Tuning Condensers:

C_3, 25 + 25 μf. split stator.

C_2, 3–30 $\mu\mu$f. Philips trimmer.

The coils are made self-supporting by using the three plugs, which are so constructed as to allow solder lugs to be mounted on them, both as connectors and as supports. The plugs are themselves mounted in a piece of perspex sheet, $\frac{1}{8}$ in. thick, and measuring 3 in. x $\frac{3}{4}$ in. So that the plugs which connect to the tapping pins shall not short-circuit some of the turns, these have about $\frac{1}{8}$ in. cut off them, making them shorter than the end ones.

TUNING AND OPERATION

When the preselector has been wired and the coils have been made, the pre-set adjustment of the coils L_2 must be made. This is very simple, and consists simply of finding the centre of the band in use and adjusting the pre-set tuning condenser for maximum response. The tuning here is much broader than that of the grid circuit, owing to the shunt resistor, and striking the exact centre of the band for peaking it up does not matter so very much, for this reason. Since the plate coils are pre-tuned, the tuning condensers must clearly be individual ones for the bands, and in the absence of switching must be mounted on the coils. Philips trimmers are recommended for use here, on account of their superior stability compared with mica-dielectric trimmers. The centre of each band can be found easily enough, even if the plate circuit is well out of adjustment, because of the broad tuning. Once the trimmers have been peaked, the rotors are fixed in position with a spot of wax, and thereafter need not be re-adjusted. All tuning, when the preselector is in actual use, is done with the grid condenser.

A SECOND DETECTOR AND SERIES NOISE-LIMITER USING AN EB34

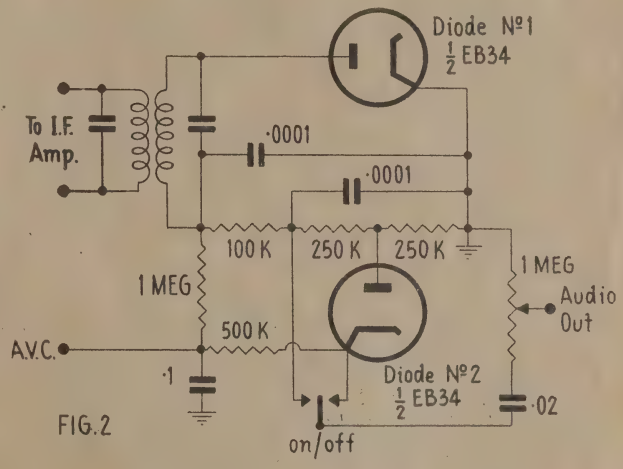
In these days of much ignition and other man-made interference, no receiver that is used for communications, amateur or otherwise, is complete without one of the excellent noise-limiter circuits that have been devised in the last few years. One such circuit that can be thoroughly recommended is presented here. It makes use of one half of an EB34, the other half of which can be used as the second detector. The circuit given should be strictly adhered to, as alteration of the values can cause some of its efficiency to be lost.

The circuit has no critical adjustments, and the threshold of operation having been fixed by the proportions of the resistor network making up the detector diode load, it is self-adjusting, and needs only to be switched in and out of circuit, as required.

The EB34 should be specially selected for low heater-cathode leakage, since the limiter diode, No. 2, has both plate and cathode connected to high-impedance points in the audio circuit.

The limiting action, with the values given in the circuit, does not allow modulation percentages higher than 80 to be passed by the limiter diode. If the values are adjusted so that higher percentages of modulation can be handled, the limiting action is impaired.

Briefly, the action of the circuit is as follows: The negative rectified carrier voltage produced by the detector diode, No. 1, is applied through an R.C. filter circuit to the cathode of the limiter diode, making this conducting. The audio output of the detector diode is therefore passed through the limiter diode to the volume control potentiometer. A noise pulse makes the plate of the limiter diode negative with respect to the cathode, since the duration of the pulse is so short that the R.C. filter in the cathode circuit does not allow the cathode voltage to alter at the same time as the plate voltage. The limiter diode is therefore cut off for the duration of the noise pulse. The latter is therefore not heard in the output of the receiver. At the same time, the voice quality is not impaired because the period during which the audio amplifier is inoperative is so short that the ear cannot detect the break. The same remark applies equally to a series of pulses, so that impulse noise is virtually eliminated.



Circuit of the noise-limiter.

If the circuit is used, as shown, to provide A.V.C., the latter will not have any delay voltage. The better scheme for most purposes is to use a separate rectifier for A.V.C., in which case the above circuit remains entirely unchanged, the terminal marked "A.V.C." merely being omitted.

The switch shown allows the limiter to be cut out of circuit if desired. In the "off" position there is twice the audio voltage available, since the output is now taken from the top of the detector load instead of half-way down, as for the limiter diode. If it is not desired to make use of the extra audio output when the limiter is not in use, the lead from the left-hand switch contact can be taken to the limiter diode plate, so that, in the "off" position, the diode is short-circuited.

PREDICTIONS FOR THE WORKING OF LONG-RANGE RADIO CIRCUITS ON AMATEUR FREQUENCIES

SEPTEMBER, 1948

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	0330 — 2130
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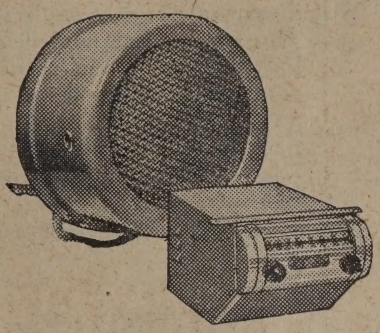

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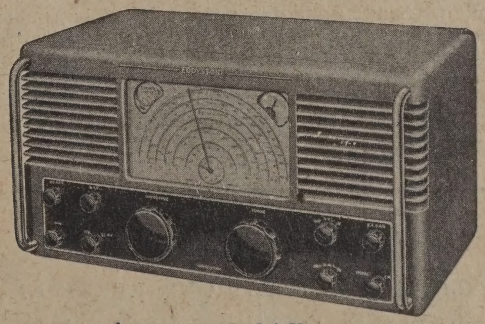

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R. & E. ABSTRACT SERVICE

(Continued from page 26.)

(Philips Tech. Review, 6, pp. 39-45, 1941). Additional application: preserving rectifiers for automatic telephone exchanges. —Philips Technical Review (Holland), Vol. 9, No. 8, p. 231. Direction-finder for locating storms. Description of apparatus used on frequency of 10 kc. to indicate direction taken by a storm. Employs two loop antennae, at right-angles to each other. These loops, through amplifiers, are connected to vertical and horizontal plates respectively of C.R.T. Flashes on screen indicate direction from which static received. Circuit diagram given.—Electronics (U.S.A.), May, 1948, p. 106.

QUALITY BROADCAST RECEIVER

(Continued from page 15.)

"narrow," since this reduces the high-frequency components of the noise, which are the most disturbing ones. In this respect, the selectivity switch is used just as a tone control would be. To sum up, the best quality of reception will be in the "broad" position, unless there is interference present, and, except for tuning, the set need be at "narrow" only when noise, from one source or another, is troublesome.

We may say in conclusion that the quality of reception given by the set will be a revelation to all who construct it; our own staff, who are notoriously sceptical in such matters, seem to have decided, with no dissentients, that it makes their own receivers sound a little shabby!

807 AUDIO AMPLIFIER

(Continued from page 36.)

sible manner for outputs from 10 to 20 watts. There is nothing in the circuits which makes either of them difficult to handle, and the usual lay-out for a push-pull amplifier can be followed with every expectation of success. An arrangement of valves and power supply components such as we have recommended for the majority of amplifiers that have been fully described in this journal will do admirably for these circuits, too.

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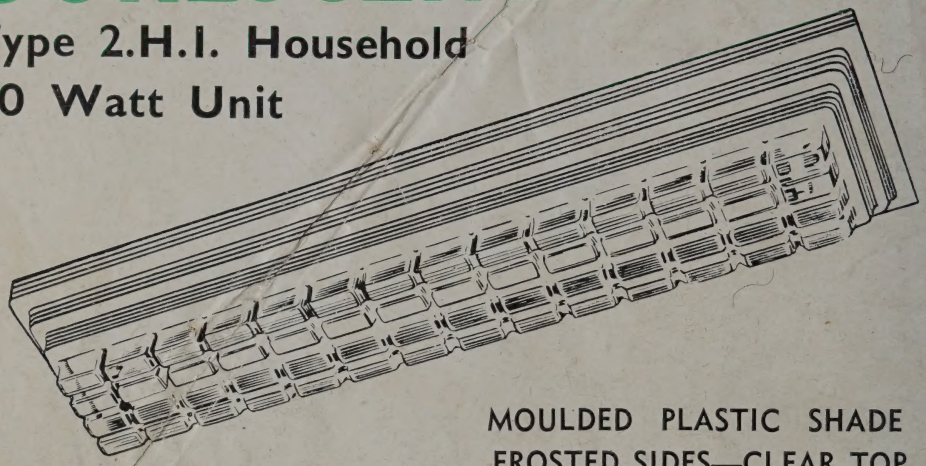

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